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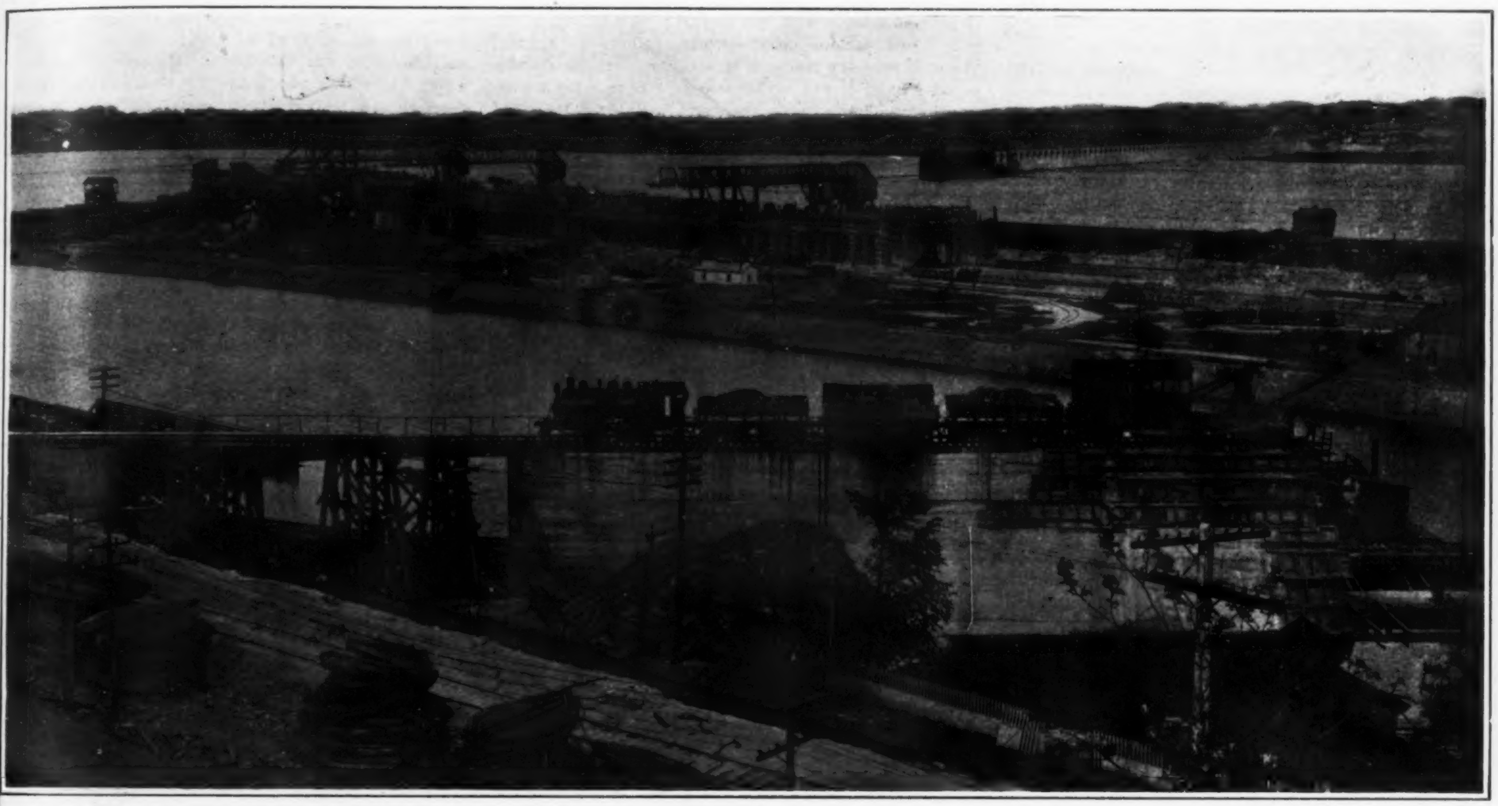


General View of the Works from the Iowa Side.

Floating Ice Passing Between Cofferdams. March 24, 1912.

DAMMING THE WORLD'S GREATEST RIVER.—[See page 87.]

The Manufacture of Chili Saltpeter*

The Technical and Commercial Aspect of a Threatened Industry

By B. Diaz-Ossa, Professor of Technology of the Nitrate Industry at the University of Chili

I.

The saltpeter industry in Chili is peculiarly interesting in its industrial and commercial organization. Its economic importance is not less, since it is the principal source of the combined nitrogen so indispensable to modern agriculture and modern industry.

The development of this industry, beginning in 1830, has been progressive, but comparatively slow; however, in 1911 2,487,000 tons were exported, comprising about 350,000 tons of nitrogen, while the yield of nitrogen from sulphate of ammonia in the same year was only 250,000 tons. The commercial value of this was $120,000,000, on which the exportation duties were $32,000,000.

Furthermore, the by-products comprised 1,100,000 pounds of iodine, worth $2,000,000, perchlorate of potassium, sodium chloride, etc.

This industry is located in a region completely desert, without vegetation, almost without water, far from the necessities of life. Hence, it has been necessary to import coal, water, and food for man and beast.

The development of the industry has created a number of important cities—Iquique, Antofagasta, Taltal, Locopilla, etc.—as also a network of railroads and ports provided with all modern facilities for loading and unloading. . . . Thus has been created a zone supported exclusively by the nitrate industry.

There are to-day 160 plants in operation, employing more than 40,000 workmen, and using annually about 600,000 tons of coal; the region contains more than 170,000 inhabitants, and consumes vast quantities of food.

The region extends from 19 degrees 30 minutes to 26 degrees south latitude, forming a narrow strip about

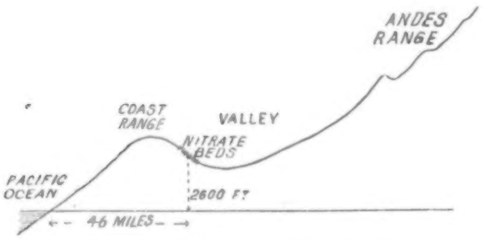


Fig. 1.—Section Through the Chilian Saltpeter Country.

forty-three miles from the Pacific Coast at a mean altitude of 3,000 feet above sea-level (Fig. 2).

The most characteristic formation is found in Tarapaca, of which section Fig. 1 gives an idea. The nitrate territory is bounded on the west by the coastal Cordillera, bordering the Pacific; it is bordered on the other side by a longitudinal valley called the Pampa of Tamarugal, then come the forerunners of the Cordillera of the Andes, and finally the Cordillera itself and the high plateaus.

The saltpeter region is on the interior slope, the eastern slope of the Cordillera of the coast.

Farther south the longitudinal valley disappears, and is replaced by traverse valleys, which run from the Cordillera to the ocean, and in which the saltpeter formation is also found. The nitrate region, where it never rains, is subject to constant winds during certain season and at certain hours of the day; at nightfall dense fogs are formed, accompanied by marked electric phenomena; the earth is radioactive in a high degree.

Various obstacles have thus far prevented systematic geographic and geologic exploration of the region; only the most accessible points are known. Hence, the deposits cannot be fully described, nor the general laws of their formation deduced.

When the north to south railroad, now in construction, is finished, it will be easier to make such studies. . . . But it has been demonstrated that in the part known enough nitrate exists to last a century.

The nitrate presents itself in the following forms: *a*, strata; *b*, impregnations and efflorescences; *c*, cavities in the limestone. Only the strata are exploited at present. A stratum consists of the layers shown in Fig. 3. The *chuca* is composed of fragments of quartz with the anhydrous sulphates of sodium and calcium; the *costra* contains some nitrate, but a less proportion than the *caliche;* it sometimes reaches 18 per cent, and its composition is analogous to that of the third layer.

The term *caliche* is applied both to the layer of soil and to its mineral contents; it is composed of insoluble materials—sand, stones, clay—agglomerated by a cement of salts, and is very hard.

It is of various colors—white, yellow, dark gray, violet, blue. Its fracture is saccharoidal; its density about 2; and it has a characteristic taste. Both composition and thickness are very variable. Its chief elements are nitrate, sulphate, and chloride of sodium; its secondary elements are potassium chloride, sulphate and nitrate of calcium, chloride, sulphate, and nitrate

Fig. 2.—Map of the Chilian Nitrate Region, Showing the Railway Lines Constructed for Its Exploitation.

of magnesium. There are also found sodium iodate, sodium nitro-sulphate or *daraskite*, calcium iodate or *lautarite*, and calcium iodo-chromate or *dietzeite*.

The analysis of two sample of *caliche* and one of costra gives the following results:

	Caliche		Costra.
	Per cent.	Per cent.	Per cent.
Nitrate of soda	36	35	17
Sodium chloride	32	6	2
Sodium sulphate	8	2	72
Insolubles	14	50	1
Sulphate of lime	8	2	2
Other salts	2	5	6

In general the *caliches* of the north, or of Tarapaca, contain more chloride of sodium than sulphate; as we go south the chloride is replaced by sulphate until we reach Taltal, the most southern district, containing more sulphate than chloride. The layers beneath the *caliche* are of little importance; they are the *congelo*, where chlorides and sulphates predominate, and the *coba*, formed of earth, stones, and a trace of salts.

The different layers rest on the primeval earth, i. e., on the rocks of the Cordillera, whose nature seems to be without importance with regard to the deposits.

In the north (Tarapaca), the *caliche* is found on the eastern slope, or interior of the coastal Cordillera on the surface of small elevations of gentle inclination bordering the longitudinal valley. In the lowest parts of this valley are found other deposits called *salares* (Fig. 4), which are composed almost exclusively of common salt with efflorescences of nitrate. In regions farther south (Antofagasta), the layers are found in the lowest part of the transverse valley; still farther south, at Taltal, deposits of nitrate have been found up to the highest part of the mountains, at 10,000 feet altitude.

Many theories—none entirely satisfactory—have been offered to explain the presence of the nitrate.

Moeliner and Darwin considered that the nitrogen of the *caliche* came from marine algæ; Müntz and Plagemann believe in microbian nitrification; Ochsenius attributes the nitrogen to guano, large deposits of which exist along the Pacific coast; Williams, Pissis, and Sundt support the theory of atmospheric origin, i. e., the union of the nitrogen and the oxygen of the air under the influence of electric discharges. The actual formation of the nitrate at the bottom of the *salares* is easily explained: The nitrate in the strata on the flanks of the hills is dissolved by the water condensed from the fogs, this solution evaporates, and by capillarity the nitrate rises to the surface of the *salar* to form efflorescences (Fig. 4).

II.

Nitrate territory is reconnoitered by the sinking of boreholes from 150 to 350 feet apart, to determine the thickness and quality of the *caliche*.

To prepare the *caliche* for exploitation the bottom of the borehole is enlarged, and powder or nitrate of soda is placed in it and exploded (Fig. 5).

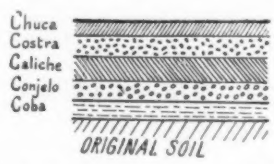


Fig. 3.—Section Through a Nitrate Deposit.

The laborers, by means of hammers and steel tools, break the fragments of rock; they thus form a cutting which permits them to extract the valuable mineral while taking care to leave the sterile at the bottom. The Chilian workman recognizes at a glance the good or bad quality of the ground and forms an accurate estimate of the contents of the *caliche*. If he is in doubt he throws a little ground *caliche* on a lighted wick and judges the contents by the rapidity and intensity of the deflagration. The *caliche* is transported to the works by carts or a small railway. The men are paid by the carload; account is also taken of the content of the *caliche*, the thickness of the useful layer, the depth at which it is found, and the greater or less ease of distinguishing the *caliche* from other elements.

Very rarely is it possible to advance the cutting parallel to itself; it always follows the form of the layers. The trenches usually open at the highest point of the territory to facilitate the transport of the ore; they proceed thence till they reach the lowest part.

The organization of the labor and the establishment of a plan of operation are of very great importance to obtain the best economic results. To obtain a good yield three factors must be considered: the mean content of the *caliche*, the mean cost of transportation, and the return from the extraction.

III.

The *caliche* is transported to the works and discharged on to the inclined plane of the machine, whence it falls directly into the crushers, to be there reduced to fragments; sometimes these latter are passed afterward between cylinders to give them a uniform size. The broken *caliche* is conveyed by conveyors or elevators to apparatus where the nitrate is separated from other salts and insoluble matters. The separation of the latter, and of chloride and sulphate of lime is accomplished by extracting with water. From the curves of solubility (Fig. 6) we see that the coefficient of solubility of nitrate of soda increases considerably with the temperature, while that of the chloride remains almost constant, and that of the sulphate diminishes

* Translated for the Scientific American Supplement from the *Revue Générale des Sciences*.

Hence, to obtain a saturated solution of nitrate it suffices to make the solution at the highest possible temperature between 110 deg. and 120 deg. Cent. On cooling, the nitrate alone will crystallize. In practice, the phenomena do not occur precisely as the theory indicates. This is due to several reasons.

A low content of nitrate in the *caliche* prevents the use of the exact quantity of water necessary, for a

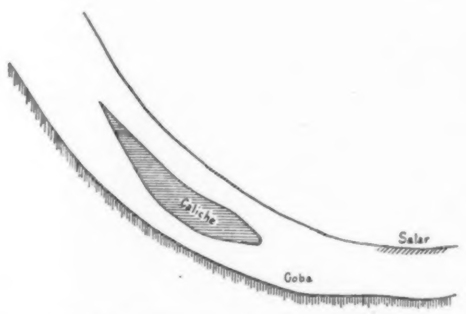


Fig. 4.—"Salares" Deposits in the Low Portion of the Valley.

clayey mud impossible to decant would be formed; therefore, it is necessary to use an excess of water. The disturbing effect of several salts on each other is the reason why the solubility curves are not the same as in the case of pure substances. If we establish the curves of solubility experimentally, making use of solutions of *caliche*, we observe numerous points of inflection, caused doubtless by the formation in the liquid of complex salts and hydrates.

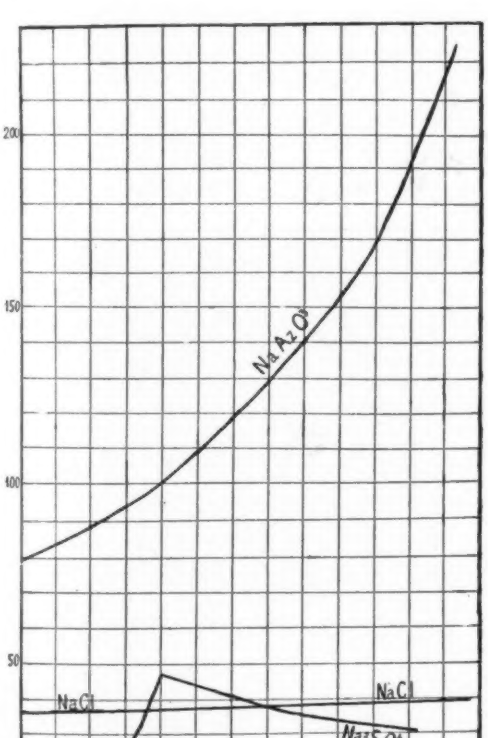


Fig. 6.—Solubility Curves of Sodium Sulphate, Chloride and Nitrate.

Finally the continuous evaporation of the liquid throughout the treatment causes the deposition not only of nitrate, but also of chloride and sulphate at the moment of crystallization.

The saturated liquid from the extraction of a *caliche* very rich in soluble salts shows the following composition, in grammes per liter:

Temperature.	Sodium Nitrate.	Sodium Chloride.	Sodium Sulphate
10 deg. Cent.......	390	180	10
30 deg. Cent.......	490	165	42
50 deg. Cent.......	594	142	40
70 deg. Cent.......	700	100	32
90 deg. Cent.......	825	96	28
110 deg. Cent.......	1,000	70	20

To remedy in part these difficulties the system of Shanks, as modified by Humberstone is made use of. In this system the liquids traverse a series of tanks—generally 6—being in contact with different substances to be extracted in each. The liquids circulate by gravity; the solutions most concentrated are displaced by those less dense; the most dilute are in contact with the most exhausted matters, and the most concentrated with those just begun on. When the tanks are properly heated we obtain, after 4 passages, a liquid concentrated at 110 degrees.

The tanks are great rectangular receptacles measuring 6½ × 7 × 33 feet, and communicate by siphons.

As we see in Fig. 7; each receptacle has 3 siphons, one for lateral transfer (transvasement) *b*, another for exterior transfer *c*, and finally an exit siphon *a*; the tanks have 2 discharge gates *f*, a lower exit of the liquid, a perforated false bottom on which rest the materials to be extracted, and finally steam serpentines *d–e* for heating.

With a system of six tanks, or *cachuchos*, 4 are in service, while one is being charged or ready for transfer, and one is being cleaned or discharged.

The solution is controlled by means of the thermometer and the densimeter, and according to tables prepared by each plant; when the liquid is sufficiently concentrated it is withdrawn by the exit siphon, water being added to the tail tank, as in transference, and the heat being at once cut off; in this way the extracted *caliche* is washed and a part of the heat is recovered.

As soon as the liquid has been withdrawn from the receptacles and the transference made to the following receptacle, the end receptacle is withdrawn from the circulation, emptied from the bottom and washed 2 or 3 times with fresh water.

The wash waters are sent into special reservoirs and used to compensate the losses of water occurring in the system.

The hot concentrated liquors are first allowed to settle for 10 minutes; though the circulation of the liquors is very slow, a part of the clay is held in suspension, and is not easily deposited. In the decantation tanks called *chulladores* the solutions, supersaturated especially with chloride of sodium, settle down and allow these salts to be deposited. From these the liquor passes to crystallizers, vessels of a large surface area and shallow depth.

The crystallizers or *bateas* are placed as seen in Fig. 8. The inclined plane at the side serves for the draining of the crystallized saltpeter. As the crystallization requires several days, a part of the liquid evaporates, with precipitation of the salts it held in solution. A product is finally obtained containing 95 to 96 per cent of nitrate, 2 per cent moisture, 1 to 3 per cent of chloride, and 0.5 to 1 per cent of sulphate and other salts.

The residue of the manufacture, or *ripios*, is withdrawn from the bottom of the solution tank, and, in spite of special washings, always retains a proportion of nitrate which may be as high as 8 per cent of its weight, and which proceeds chiefly from the liquor with which it is impregnated.

It is not possible to wash it out more completely, for the system of lixiviation in use permits the use of only a certain quantity of water in circulation. The effort is being made to wash the residues further by employing evaporation apparatus for the concentration of weak liquors. Numerous difficulties have been met with chiefly technical in the evaporating apparatus, and most of it has been rapidly destroyed. Experience has proved, however, that with certain arrangements satisfactory results may be obtained. The problem of evaporation in this industry is still to be solved.

IV.

With a series of six solution tanks 5 operations can be concluded in 24 hours, i. e., the liquid can be withdrawn 5 times. Each tank is in use about 25 hours consecutively. The consumption of water varies from 8 to 15 gallons for 100 pounds of the nitrate produced; the mean consumption of coal in all the plants is 25 pounds per 100 pounds of nitrate.

In general, to produce a minimum of 5,000 tons per month with *caliches* of 20 to 25 per cent, solution tanks having a total volume of 31,500 cubic feet are needed. A plant of this capacity costs about $500,000.

With the system thus far employed *caliches* having an average content of less than 18 per cent cannot be

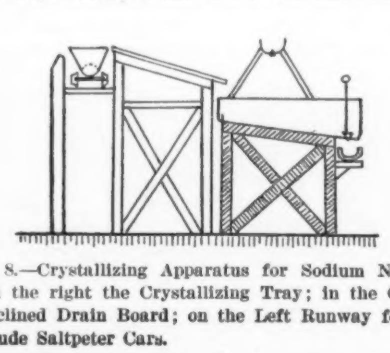


Fig. 8.—Crystallizing Apparatus for Sodium Nitrate. On the right the Crystallizing Tray; in the Center Inclined Drain Board; on the Left Runway for the Crude Saltpeter Cars.

treated; the treatment of the raw product is, in fact, regulated by the cost of the coal consumed.

With *caliches* having a content of 50 per cent nitrate, and no insoluble matter, the consumption of coal does not exceed 4 pounds per 100 pounds of nitrate produced, but for the same amount of product *caliches* of 18 per cent will consume 25 pounds of coal.

The losses of heat may be classified as follows: *a*, that resulting from evaporation of water; *b*, that absorbed and lost in the residues; *c*, losses in heating up apparatus; *d*, loss due to an elevation of temperature which does not accord with the best solution of the nitrate; *e*, losses by radiation.

In analyzing these losses we come to the conclusion that they are increased with the difference of temperature between the atmosphere and the liquid at the end

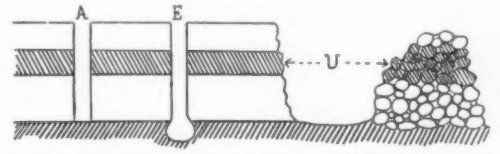


Fig. 5.—Diagram Illustrative of the Method Followed in Exploiting a Saltpeter Bed. *A*, Explorative Borehole; *E*, Borehole Enlarged at the Bottom to Receive Charge of Explosive; *U*, Layer Containing Valuable Products.

of the operation, and also with the decreasing quality of the *caliche*.

The pound of nitrogen in nitrate of soda put on board ship on the coast of Chili comes to at least 8 cents, we must reckon on a mean of 10 cents.

This cost of production is thus divided:

	Per cent.
Export duty	41
Sundries (sacks, oil, fodder, powder, etc.)....	6
Transport of the product on board and commissions....................................	11
Administration and general expenses	3
Labor	19
Coal	11
Amortization of the land	9

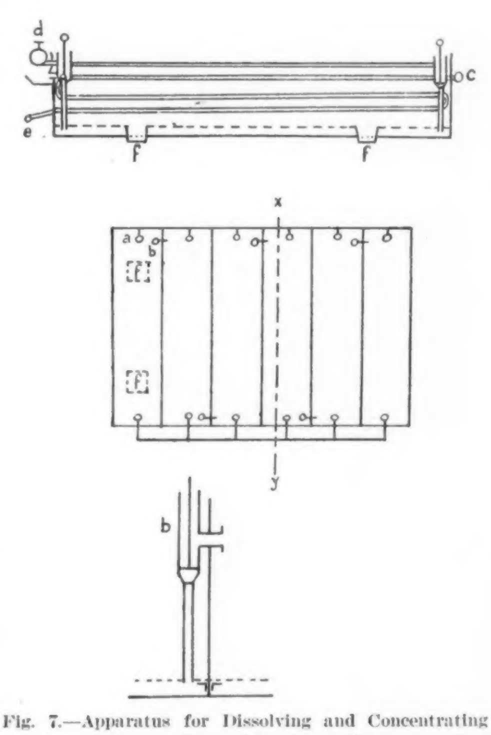
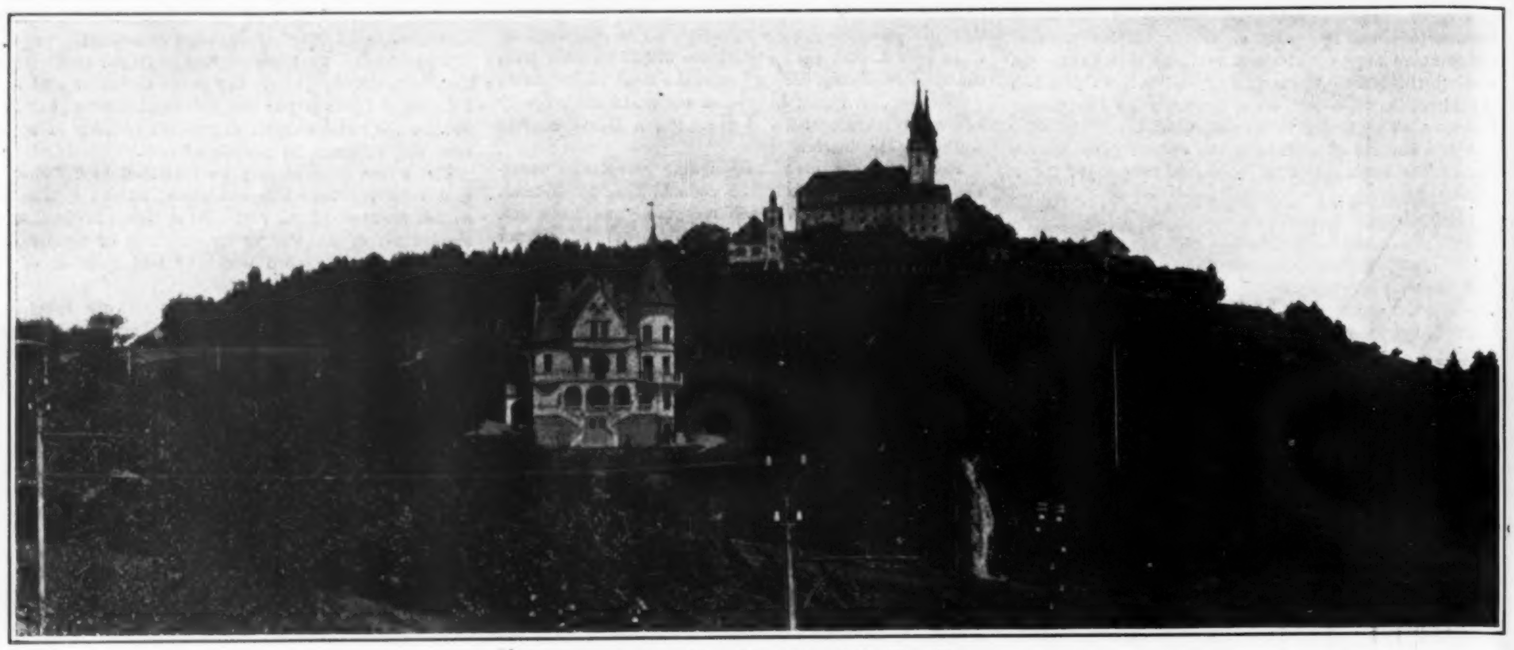


Fig. 7.—Apparatus for Dissolving and Concentrating Sodium Nitrate. Upper Drawing a Transverse Section along the line *x–y* of the second drawing (plan). Lower Illustration a View of a Transfer Syphon.

The first four figures are very difficult to reduce, being quantities independent of all systems of elaboration and extraction; the last three, on the other hand, are variables which depend absolutely on the system of operation, and it is to them that attention must be directed in endeavoring to reduce the price. Systems must be sought which will exact less coal and less labor.

The cost of a pound of nitrogen transported to Europe is 10 cents at a minimum, the mean average is about 12 cents.

From this brief exposition of the actual state of the nitrate industry in Chili it would seem that the day of the exclusive rule of synthetic nitric fertilizers is still distant.



The Poestlingberg, Near Linz, Site of the New Museum.

A Museum of Underground Life

And the "New Grotto" at Adelsberg

THERE has recently been opened at Poestlingberg near Linz (Austria) a museum which is the first of its kind in Europe, being entirely devoted to specimens illustrative of life underground.

The collection, while interesting to the layman, is of special value to the trained scientific observer, supplying him with precious material for research both in contemporaneous biology and in palæontology.

Skull of the Prehistoric Cavern Bear.

The animals inhabiting caverns are, for the most part, members of inferior biological orders, such as amphibia, articulates and mollusks, which in the course of numberless generations have adapted themselves to the eternal night in which they live. While their eyes, by a gradual atrophy, have become practically blind, their organs of touch, smell and hearing have, on the contrary, undergone an abnormal development.

The museum has a very complete collection of this remarkable fauna, comprising representatives of coleopters, arachnids and crustaceans.

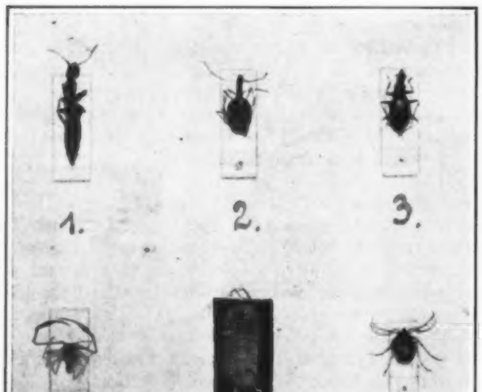
A number of specimens of the curious cavern proteus, a blind salamander inhabiting the stygian waters of an underground river of Carniola, are kept in a special aquarium.

The fossil fauna of caverns includes representatives of higher biological classes, such as the cavern bear (*Ursus spelacus*) of the Mokrica Cavern in Carniola. A skull of this animal forms one of the exhibits.

Utensils and all sorts of accessories used in connection with the difficult and oftentimes dangerous investigation of caverns, complete the collections of this interesting museum.

A very complete picture gallery illustrates the caverns of Austria, with their beautiful stalagmite formations, their abysmal lakes and ice-clad domes. While a very full collection of maps gives an idea of the enormous dimensions of these underground domains, one of the exhibits is a fine model of the famous Adelsberg grotto. It may not be amiss to devote some space to a few notes regarding this grotto.

In caverns abandoned by their rivers, such as the stalactite galleries of the Adelsberg Grotto, the growth of the underground halls has come to a standstill, the water having ceased its corrosive action, while the water trickling through rather tends to reduce their dimensions by the deposition of dissolved lime. Under such circumstances the grottoes form very stable structures, so that the powerful earthquake which in the night preceding Easter Sunday night in 1885



Some Specimens of Underground Insects, Arachnids and Crustaceans.

wrought so much devastation to life in Naibach and the whole of Carniola, left the caverns of Adelsberg untouched.

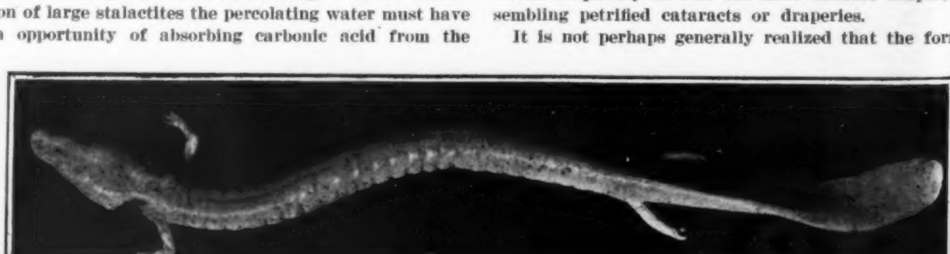
While stalactites are of fairly general occurrence in such caverns, conditions have been particularly favorable for their production at Adelsberg. For the formation of large stalactites the percolating water must have an opportunity of absorbing carbonic acid from the vegetable soil, which opportunity is not afforded by bare rocks devoid of vegetation; moreover, it must on its downward way pass through a lime layer of sufficient thickness to corrode the rock and to charge itself with calcium carbonate. This is why caverns having thin ceilings do not show any appreciable stalactite formation. Finally, the water trickling down must, in the cavern itself, be made to deposit by evaporation

Model of the Adelsberg Caverns.

the lime carried along. Now, in a cavern containing pools or streams of water the air, being too damp for the percolating water to evaporate, exerts a corrosive action; on the contrary, in the dry air of a cavern abandoned by its river, especially if natural ventilation be as efficient as it is at Adelsberg, the water trickling out of the fissures evaporates partly or wholly and disengages the lime dissolved therein.

This is how the icicle-shaped stalactities are formed on the ceiling, toward which the stalagmites grow up from the floor, and the combination of both forms slender, delicate columns or mighty pillars that seem to carry the ceiling of the cavern. The percolating water covers the walls with stalactite incrustations which frequently assume the most delicate shapes, resembling petrified cataracts or draperies.

It is not perhaps generally realized that the forma-



The Blind Salamander Which Inhabits the Underground Water of Carniola.

The "Thousand and One Nights" Hall in the New Grotto.

The "Mortuary" Hall in the New Grotto, Adelsberg.

tion of the variegated stalactites required a very extended period of time. According to the English investigator Body Dawkins, the rate of growth of the stalactite layers in the calcareous grottoes of Yorkshire, ranged between 0.05 and 0.24 inch for a period of 35 years, James Farrer finds much higher figures for the "Jockey Cap" stalagmite of the Ingleborough cavern. Measurements taken at Adelsberg, however, showed that a stalactite there would take between 15,000 to 25,000 years to rise to one meter in height.

In view of these facts the marvels of the underground worlds seen on a visit to Adelsberg, especially the New Grotto (illustrated in our engravings) assume especial interest. The New Grotto, the most precious treasure of Adelsberg, is situated at the very end of the row of caverns behind the Calvary Mountain. It mainly runs in a northward direction, and as it were, forms an extension of the Adelsberg Grotto in its main axis. It may be taken for granted that the Polk River (which has dug out the main grotto) before its issue was obstructed by collapses and found its way toward the northern caverns and precipices which it traverses to-day in a lower story. Immediately behind the splendid stalagmites known as the "Big Asparagus" a hardly recognizable path branches off, leading down into the Débris Hall with its giant rocks. In the eastern wall of this hall opens the entrance to the New Grotto, to which one finally ascends by the aid of two iron ladders 23 feet in height. An iron trap-door protects the grotto against intruders, and its priceless stones against depredation.

The New Grotto satisfies the dreams of the boldest imagination. It is 1,490 feet in total length, of which the central 465 feet are densely set on all sides with the most splendid formations. Where the calcite crystals form on the lime floor and have not yet produced any appreciable stalactite formations, their existence is evidenced by the crackling noise they make under the visitors feet. Every step forward into the New Grotto opened up a new vista. The halls shine with a beautiful white luster, and from the floor there rise slender stalagmite pillars, while the walls are decorated with beautiful curtains varying in hue between a snowy white and a dim yellow and reddish. From the white ceiling descend countless short cones, forming as it were a petrified rain.

To the admiring visitor making his way into the mountain with his miner's lamp, among the mighty shadows of stalactite pillars, in the absolute stillness of the everlasting night, interrupted only by the soft sounds of falling drops—stone after stone and pillar after pillar will assume some form and likeness, some life of its own. The center of the lengthy central section of the Grotto is occupied by a huge white stalagmite reaching down sleeve-like on a pillar trunk, surrounded by a number of smaller stalagmites. The walls are abundantly covered with white, gray and yellowish stalagmites, protruding in round vaulted masses from the ceiling and reaching in numerous tubes, and comes as far as the floor. From the ceiling itself are hanging numberless stalactites, forming in the angles of the wall many niches, the decorations of which remind one of all the architectural charms of the Gothic style. Nowhere throughout the hall is the bare limestone to be seen, the very floor being decked with white crystals. The wealth of forms to be noticed everywhere, and especially the striking likeness shown by many formations with production of human skill, or even with organic forms of the world above appeals strongly to the imagination.

In conclusion, the writer wishes to express his indebtedness to Mr. G. Lahner, president of the Society for Cavern Research, who has supplied him with much of the material here presented, and shown him many other courtesies in the preparation of this article.

American Road Congress

While there are to be many popular features at the American Road Congress, which is to be held on the Million Dollar Pier in Atlantic City, September 30th to October 5th, highway engineers and others interested in the actual construction of public roads will be chiefly interested in the construction and maintenance section, of which Col. E. A. Stevens, State road commissioner of New Jersey, is chairman. Both President Taft and Gov. Woodrow Wilson are to make addresses at the congress, and a number of ambassadors, army and navy men, governors of States, and other officials will be among the speakers.

Arrangements are being made to have all the State highway officials, county commissioners, mayors of cities, commissioners, county and State judges, and members of State legislatures present at the congress. It is being pointed out by the officials of the great road congress that a great deal of money can be saved to counties and municipalities by having their road and street officials attend the American Road Congress at the expense of the State, county or city. The officials can see and critically examine every known labor and money saving device and equipment in competition. They can see and critically examine every known road material in competition with all other known road materials; can study the government exhibits, obtain without cost practically a library of National, State and commercial publications which will be on exhibition, and can hear addresses and discussions by men whose advice on a commercial basis would be worth thousands of dollars.

Every private corporation deems it wise to send representatives to various points in this country and Europe to study methods and equipment. If cities and counties find it profitable to pay the expenses of their representatives to a single city to examine methods and materials, it is argued that it would be a far better outlay of the public funds to send an official to the American Road Congress, where every phase of the road movement will be shown in models and explained in lectures under the same roof.

Every feature of street, park, road and bridge construction, maintenance, and administration, will be thoroughly dealt with by the greatest authorities in their respective fields. Prof. William H. Burr, dean of engineering of the Columbia University, will read a paper on highway bridges; George W. Tillson, consulting engineer to the borough of Brooklyn and one of the foremost authorities in the world on street paving, will make an address on street paving; Gen. John C. Black, chairman of the United States Civil Service Commission, will devote his attention to the merit system in road administration. Associated with Col. Stevens in the arrangement of the programme for the construction and maintenance section are: Col. William D. Schier, chairman, State Highway Commission of Massachusetts; John A. Bensel, State Engineer of New York; Austin B. Fletcher, State Highway Engineer of California; P. St. J. Wilson, State Highway Commissioner of Virginia; W. S. Keller, State Highway Engineer of Alabama; Onward Bates, Past President of the American Society of Civil Engineers; Dr. Edgar Marburg, Dean of Engineering of the University of Pennsylvania; John R. Rablin, Chief Engineer Metropolitan Park Commission of Boston; Maj. William V. Judson, U. S. A., Engineer Commissioner of the District of Columbia, and others of equal note.

The construction and maintenance section is but one of more than a dozen sections of the congress. Among them will be sections devoted to finance, legislation, railways and their relation to public roads, and highway engineering in educational institutions. Men who are as prominent in their own field as those in charge of the construction and maintenance section are prominent in their particular field, are in charge of the other special sections of the congress.

Making Writing Paper Transparent.—The *Buchdrucker Woche* gives the following receipts for the above purpose: In a suitably large enamel vessel, place 50 parts of dammar rosin (purchased in large clear pieces and pulverized), 80 parts of colophony rosin (also in pieces which have been pulverized), 25 parts of best camphor, 5 parts of golden-yellow Venice turpentine. The vessel must be substantially larger than the volume of the materials so that when they are brought to a fluid state it will be only half filled. It is heated on a water bath until contents are melted, but taking care that they do not catch fire. Should they do so, the lid must be quickly placed on the vessel so as to put out the flame. When the solution is ready, the paper is coated on one side with a soft brush and laid out horizontally on frames to dry. Should the paper not be sufficiently transparent after this treatment, it should be coated again more strongly with the solution, and when needful even a third time, until a uniform transparency is attained. A second receipt consists of 10 parts paraffine, 20 parts Canada balsam, 5 parts camphor, and 153 parts rectified spirit. With this formula it is necessary to be careful that the solution does not become dirty, and some care is needful in handling it as the turpentine is very inflammable. The vessel should be kept well closed because through evaporation of the turpentine the varnish becomes too thick. In conclusion, it should be mentioned that oily or fatty masses of paper after a short time give off a rancid smell, which does not occur with paper treated with resinous solutions.

Dangers in the Celluloid Industry.—That the peril of celluloid working is not confined to its inflammability alone, is pointed out in the new regulations in regard to the working and finishing of celluloid articles, issued by the Ministry of Saxony. According to a statement accompanying these regulations, there is also the danger of poisoning by prussic acid, which is produced when celluloid burns. Experiments, made by the Hygienic Institute at Leipzig, have shown that 5 grammes of celluloid scraps ignited in the open air will produce about 0.05 grammes of prussic acid, a quantity sufficient to kill one person. The danger is increased when celluloid working is done in the small rooms of private dwellings with insufficient ventilation. The new regulations forbid the manufacturers to give out more than 13 pounds of material at a time to any one family employed in home finishing, and also they are to point out to these people the danger connected with this work.

The Second Law of Thermodynamics*

With Notes on the Thermodynamics of the Atmosphere

By Charles P. Steinmetz, Chief Consulting Engineer, General Electric Company

The second law of thermodynamics may be expressed in the form: "In any cyclic process, the sum total of unavailable heat energy increases." Thus, if we transform electrical to mechanical energy and backward, we do not get back the total amount of energy, but some of it is converted into heat. Of this heat energy at least a part can never be re-transformed into any other form of energy, i. e., it has become unavailable. Or the law may be expressed: "Without expenditure of some other form of energy, heat flows only from higher to lower temperature;" that is, from a higher heat level to a lower heat level. In this form the law is easiest to grasp; just as water, without expenditure of outside energy, flows only from higher to lower level.

The result thereof is that the total heat energy can never be used in any case; but that amount which is still heat energy when the lowest heat level or temperature has been reached can not be transformed except by the use of additional energy, i. e., it has become unavailable. Thus, of the total heat energy in the superheated steam issuing from the boiler, only that corresponding to the temperature range from admission temperature to the temperature of surrounding space can be used; but the much larger amount of heat energy which is still contained in the steam exhausting into the condenser at atmospheric temperature is unavailable.

To some extent availability is relative. The heat energy in the steam exhausting into the condenser at atmospheric temperature, which is unavailable under ordinary conditions, would be available in part if we could exhaust at the temperature of liquid air; and of the heat energy remaining in the exhaust at liquid air temperature, a further part could be transformed by exhausting at the temperature of liquid hydrogen, etc. Even between the limits of atmospheric temperature appreciable variations of available energy, and with it differences in the efficiency of steam turbines, etc., are noticeable. However, the total heat energy could be made available only by dropping down to the absolute zero of temperature, and as this can not exist, all the energy, which is still heat energy at the minimum temperature of the universe, has become absolutely unavailable, i. e., it can never be used without the expenditure of some other form of energy.

An analogy is given by water-power. Of the energy of a water course, only that represented by the difference in height between the upper level and the lower level is available at the point of development. However, some miles distant, a still lower level may exist, and further hydraulic energy made available by it; but finally the ocean level is reached. Here the water still contains an enormous amount of gravitational energy—that corresponding to its distance from the center of the earth. This, however, is now absolutely unavailable, since no lower level exists into which the water can be discharged, and outside energy would have to be expended to make such a lower level.

The result of this functioning of the second law of thermodynamics is that the temperature crests in the universe are leveled off, the temperature valleys filled up, the amount of unavailable heat energy (that below the bottom of the temperature valleys) is increased; in other words the temperature of the universe tends toward a uniformity, at which all the heat energy has become unavailable. The temperature differences in the universe are thus maintained only through the expenditure of other forms of energy, and other energy is thus continuously poured into the gulf of heat energy in producing available heat energy through temperature differences, which again are continuously leveled off and the heat energy made unavailable by the functioning of the second law of thermodynamics; but no return path exists from the unavailable heat energy to other forms of energy.

The outcome of this unidirectional transformation law must be that finally all the other forms of energy will have been converted into heat energy, and all the heat energy have assumed a uniform temperature level, i. e., become unavailable. This means that all the energy of the universe must finally be converted to unavailable heat energy, and if the second law of thermodynamics holds universally, no return exists from this state; hence, the universe must finally run down, just like a clock. All energy transformation will stop, i. e., all motion will cease and the universe will be dead. The energy will still be there—the law of conservation of energy will not have been offended—but as unavailable heat the energy will be dead. It is true that if we define energy as that entity which can do work, it is questionable whether the unavailable heat energy of the dead universe, which can never do any work, can still correctly be called energy.

The second law of thermodynamics is well founded on our experience. The reasoning from this law as to the death of the universe is logical. At the same time, the conclusion that the universe must run down is not reasonable. If the universe is eternal, has existed since infinite time, then it should have run down an infinite time ago. But if it is not eternal, but had a beginning, what was before? How could energy begin without offending the first law, that of the conservation of energy? Thus, in the final reasoning, we arrive at a contradiction.

The explanation may be either that we have attempted to reason beyond the limits of the capacity of the human mind, which, being finite, always fails in the attempt to reason into the infinite, or it may be that the second law of thermodynamics is not of universal application, is not a general law of nature, but is of limited application only. In the following columns I wish to show that the latter is the case. A single exception obviously would be sufficient to show that the second law of thermodynamics is not a universal law, and that the conclusion regarding the death of the world, based on this law, are thus not justified. As the thermodynamics of gases is far simpler and more completely known than any other branch of thermodynamics, it would offer the most promising field of study.

The kinetic theory of gases is probably as fully and conclusively proven as anything can be by the inductive method of science. According to this theory, the heat energy of a gas is the mechanical energy of the irregular molecular motion: that is, the $\frac{1}{2}\ m\ v^2$ of the molecules and the atoms in the molecules. The second law of thermodynamics then is nothing but the application—the natural consequence of the operation—of the law of probability. If we bring together two gases of different kinetic molecular energy, i. e., of different temperature, such as a liter of air at 30 deg. Cent. and a liter of air at 10 deg. Cent., in such a way that the molecules can exchange their motion, i. e., heat can flow between the gases, it is obvious that, in an interchange of velocity between the molecules, one having a velocity above the average is more likely to lose than to gain velocity; a molecule with less than average velocity is more likely to gain than to lose velocity. The result of the interchange of velocity—or rather of kinetic energy, in accordance with the laws existing between bodies, probably the law of gravitation—thus is an averaging of the kinetic energy, i. e., an equalization of the temperature—in the above instance to 20 deg. Cent. for both liters of air. However, the result of the operation of the law of probability cannot be a perfect equalization of the molecular energies so that all the molecules have exactly the same energy, but sometimes a fast molecule may still gain energy (although it is more probable to lose), or a slow molecule may lose. The result thus would be a distribution of the kinetic energies between all the molecules in accordance with the probability law; and the temperature then represents, or is, the average kinetic energy of the molecules—is represented by an average molecular velocity. This is the velocity found most frequently among the molecules; but all higher and lower velocities exist, becoming, however, more and more rare the further they differ from the average velocity, in accordance with the probability law.

Causing heat to flow from a lower to a higher temperature then means separating the faster from the slower molecules. Experience, expressed by the second law of thermodynamics, says that this can be done only by the expenditure of outside energy. However, such a separation of the fast from the slow molecules without expenditure of outside energy would in no way contradict the law of conservation of energy, as Maxwell has shown. Assume that we have a volume of gas at constant temperature—the two liters of air at 20 deg. Cent. resulting from the previous illustration—and have a partition to divide the gas volume in two parts. This partition may be perforated by numerous minute doors, which we assume to have no weight and to move without friction, so that no energy is required to open and close them. Assume now that at every such door we place a demon, who opens the door whenever a fast molecule comes from the right, or a slow molecule from the left, and lets this molecule through; but does not open the door for a slow molecule from the right, or a fast molecule from the left. The result would then be, that gradually the fast molecules would accumulate in the left, and the slow molecules in the right section of the space; that is, without expenditure of outside energy, but through the intelligence of the demons, heat energy would flow from the lower temperature on the right to the higher temperature on the left side of the partition, against the second law of thermodynamics.

Now these demons exist in nature. Every cosmic body is such a demon, and separates the fast from the slow molecules, keeping the latter and sending the former out into space, and thereby causing heat energy to flow into space at a temperature far above its own temperature. Consider for instance our earth. In the uppermost regions of the atmosphere, assume a molecule which happens to be moving in an upward direction, and does not happen to approach another molecule so closely that its direction of motion is changed. Such a molecule will move upward, until its motion is stopped by the force of gravity, by the attraction of the earth, when it falls back again. If, however, the upward velocity of the molecule is sufficiently high—above a certain critical value—then this molecule escapes from the attraction of the earth into space, and never comes back. This critical velocity at which a molecule escapes from the earth is 11,000 meters per second. Assuming the average velocity of the molecules of the air, corresponding to an average terrestrial temperature of 10 deg. Cent. or 283 deg. absolute, as 750 meters per second, then the velocity of 11,000 meter seconds corresponds to a temperature of $283 \times \left(\frac{11,000}{750}\right)^2 = 60,000$ deg. Cent. That is, the molecules which the earth sends out into the universe have a kinetic energy corresponding to a temperature of 60,000 deg. Cent., or as we may say, by the escape of these molecules heat energy flows from the temperature of the earth, 10 deg. Cent., into a temperature of 60,000 deg. Cent.

This brings up an interesting feature. Since the temperature of the earth steadily decreases with increasing altitude, we usually think of cosmic space as extremely cold—near the absolute zero of temperature. Empty space obviously has no temperature, since temperature is an attribute of the matter in space. Judging the temperature of cosmic space by the kinetic energy of the molecules which have escaped into space from the larger cosmic bodies and which traverse space in irregular motions, we would be led to the conclusion that, far from being extremely low, it would on the contrary be of an inconceivably high value, probably several hundred thousands degrees centigrade. This conclusion would better agree also with the very simple line spectra of gaseous matter in space, as shown by the nebulæ.

We may ask, however, whether the kinetic energy of a molecule which, due to its high velocity, has escaped into cosmic space, can still be considered as heat energy. Heat energy is the kinetic energy of irregular molecular motion. The difference between the heat energy of a gas and mechanical energy thus lies in the irregularity of the motion and the size of the moving particles, which is such that only the resultant effect of the mechanical motions of large numbers of moving particles can be perceived. Irregularity of motion, however, is relative; for, if we consider a single molecule which has escaped into space by reason of its high velocity, we cannot attribute any irregularity to its motion. That is to say, its kinetic energy cannot further be considered as heat energy; but the kinetic energy of the molecule, which was heat energy while the molecule moved in a mass of gas together with other molecules, is mechanical energy of cosmic motion, and the molecule is a cosmic body, traversing space under the laws of gravitation, but not subject any more to the law of probability of mass action, i. e., to the second law of thermodynamics.

This brings us to the question of the limitation of the conception of heat energy, but for this purpose we do not need to go to cosmic space. If we consider the vacuum tube, and go to the highest vacua—the cathode ray vacuum and beyond—the distances between the molecules become so large that the free path of each molecule becomes appreciable, and the action of the kinetic energy of the individual molecule becomes

noticeable. But as soon as this is the case, the kinetic energy of the molecule cannot well be considered as heat energy any more, and the laws of thermodynamics, which after all are the laws of probability of a mass of moving bodies, begin to fail in their application. Thus, Crookes proposed to recognize this condition of a high vacuum, where the molecules act as individuals, as a fourth state of matter. This again throws a side light on the question of the temperature of the cathode ray tube, or the mercury arc in a vacuum. At these very high vacua we may say that we cannot speak of a temperature at all, and heat energy, as the resultant mechanical energy of molecular motion, ceases to exist with the separation of the molecules to such distances that their resultant effect vanishes when compared with their individual actions. When, however, the kinetic molecular energy ceases to be heat energy, the second law of thermodynamics, which is the application of the law of probability, also ceases.

Spontaneously, heat energy flows from a higher to a lower temperature, until equality of temperature is reached, and most methods of temperature measurements are based on this law. However, even this law is correct only within certain limitations. For instance, in the atmosphere of our earth, where there is continuous interchange of heat energy and the air is never at rest, nevertheless no equalization of temperature occurs, and there is no tendency to a condition of equilibrium at constant and uniform temperature—the condition of equilibrium is a definite and very decided decrease of temperature with increase of altitude. If we assume that no heat energy is supplied to or withdrawn from our atmosphere, and that the atmosphere is very thoroughly mixed so as to reach equilibrium condition, then (if for a moment we leave out of consideration the effect of condensation of moisture) the equilibrium condition would be a uniform decrease of temperature with increasing altitude, down to the absolute zero of temperature at an altitude of about 29 kilometers (about 18 miles). And the reason for this is not far to seek. In the equalization of temperature, whether by the molecules in bulk, in air currents, or by the motion of individual molecules in heat conduction, any upward motion of a molecule is accompanied by a retardation due to the attraction of the earth, and thereby a decrease of kinetic molecular energy, i. e., of temperature. Any downward motion is accompanied by an acceleration by gravity, and consequently by an increase of kinetic molecular energy and therefore of temperature, and equality of temperature throughout the entire atmosphere is thus impossible with freely moving molecules: the theoretical condition of equilibrium is the adiabatic temperature distribution with the altitude.

In accordance with this theoretical law of atmospheric equilibrium, the atmosphere would have a finite limit at about 29,000 meters, at which limit air pressure, density and temperature fall to zero. We know, however, that an appreciable atmosphere extends very far beyond these limits, and for the upper regions of the atmosphere, this theoretical law of equilibrium thus fails.

However, this equilibrium condition is based on thermodynamic relations, i. e., is that corresponding to the average velocity of the air molecules. The molecules which have a higher velocity than the average corresponding to the temperature are capable of reaching up to correspondingly higher altitudes—beyond those that would limit the extent of the atmosphere if all its molecules had the same average velocity. Thus, even in our own atmosphere, and without going beyond it into cosmic space, the law of gravitation is doing the work of Maxwell's demons in separating the faster and the slower molecules, and collecting the former in the higher regions of the atmosphere. Thus, the second law of thermodynamics does not apply to the atmosphere of the earth, since kinetic molecular energy is transferred from the regions of lower molecular energy to regions of higher energy; that is, heat energy flows from lower to higher temperature, or rather flows against the thermodynamic temperature equilibrium.

Furthermore, this phenomenon is not beyond the limits of heat energy—that is, in the range where the molecules act as separate masses—and their kinetic energy thus is not heat energy but mechanical energy. In the present case, however, the phenomenon applies to the resultant kinetic molecular energy, that is, to the temperature. The average kinetic energy, and thus the temperature of the upper regions of the atmosphere, must be higher than that which corresponds to the theoretical thermodynamic equilibrium.

Thus we are led to the conclusion that the second law of thermodynamics is not a universal law of nature, but applies only within the limited range of thermodynamic engines from which it has been derived. It does not apply to the universe as a whole; and the conclusions derived from it, that the universe must finally come to a standstill, are not justified.

Damming the World's Greatest River

Harnessing the Mississippi for Two Hundred Thousand Horsepower

By H. S. Rogers

The world is always interested in superlatives. The greatest watershed on our land is that of the Mississippi River; and there is being built the largest dam that the world has seen to impound the waters of the greatest river, and the point of attack is at the lower end of the lower rapids. There are two rapids in the Upper Mississippi and the lower one is known as the Des Moines Rapids, because it ends at the mouth of the Des Moines River. At this point the States of Illinois, Iowa and Missouri find their boundaries marked by the two rivers named.

Civilization is a coral isle in the sea of time, accretions from the thought, the words and deeds of men; and, humanity had to come through the age of stone, the age of wood, the age of steel and into the combined ages of concrete and electricity before it was time for the gigantic enterprise now nearing its completion at Keokuk.

Let us, at the start, have an understanding regarding this dam. Its object is to use the fall of water in the rapids to create 225,000 kilowatts, electrical, or 300,600 horse-power energy for commercial purposes in the Mississippi Valley. It is not a government enterprise, although the government is supervising it for reasons that will be explained later, and eventually will own a part of the work under construction. The Mississippi River Power Company, incorporated at Keokuk, Iowa, is the proprietor. The cost will be in the neighborhood of $25,000,000 and this money was obtained by the sale of stocks and bonds in this country and abroad. The estimate is that the work will be completed by July, 1913, or less than a year from the time of publication of this article. It is more than 75 per cent completed at the present time. All the work has been done by administration, no contracts let for any of its construction.

Naturally the public looks upon the dam as the spectacular feature of this great work, but in reality it is overshadowed by some of the other engineering problems that Mr. H. L. Cooper, the engineer of the project, had to solve. Besides the dam, there is being constructed the immense power house, the largest lock in the world, the largest dry dock ever built in fresh water, a sea wall to elevate a railroad track, an ice fender to protect the intake of the power plant, all of it one concrete monolith with a total linear measurement of 13,185 feet, or two and a half miles. This is the greatest single installment of concrete ever laid for any purpose.

Within a few weeks, the hydraulical end of the work will have been completed and a Boston firm of electrical engineers will take up their labors of installing a vast and new design of electrical equipment. Bolts of lightning, forged by the restrained and struggling old "Father of Waters," will go flashing up and down the valley from Davenport on the north to St. Louis on the south, where it will do such prosaic things as move street cars, light houses, spin, wash dishes or all else its master wills.

A simple definition of horse-power is that power which will raise 33,000 pounds, dead weight, one foot from the ground every minute of time. This region is the heart of the American corn belt, and its people have grown sluggish in possession of a soil so rich that it almost bursts itself with growing. Not yet half aroused, they still are rubbing their eyes over the boisterous doings of Cooper and his men. Try to think of the vast blow that these 225,000 kilowatts will strike, every 24 hours, for industry, and how it will affect conditions in the slumbering corn belt.

Every great project is at first only a thought incubated in a human brain, and its development into a concrete thing is often attended with romances more thrilling than the acts of a master play. The essential foundations of drama are set forth as time, place and a reason. Having these in our drama of the Mississippi dam, it is time to move the characters about. Seventy-five years ago the valley lands were being exploited for settlement, and the "boosters" advertised these rapids as suited to power purposes. The age of steam had just begun and by "power" they meant the ancient water-wheel. The first report to the United States Government on the possibilities of the Mississippi River rapids for power purposes was written by Robert E. Lee, the famous Confederate leader, then a young lieutenant in the United States army and stationed in the locality.

Following settlement of the land came the era of steamboat traffic on the river, and the rapids appeared to be a menace instead of a benefit to human industry. Mark Twain was a printer on a Keokuk newspaper at that time, and he writes that merchandise was piled "mountain high" on the levee while awaiting transshipment to small boats that would carry it over the rapids. To meet this condition the government spent several millions of dollars in building a three-lock canal, twelve miles long, that is still in use. This is its last year, however, as Cooper's dam will make a great pool that will bury the canal many feet under water.

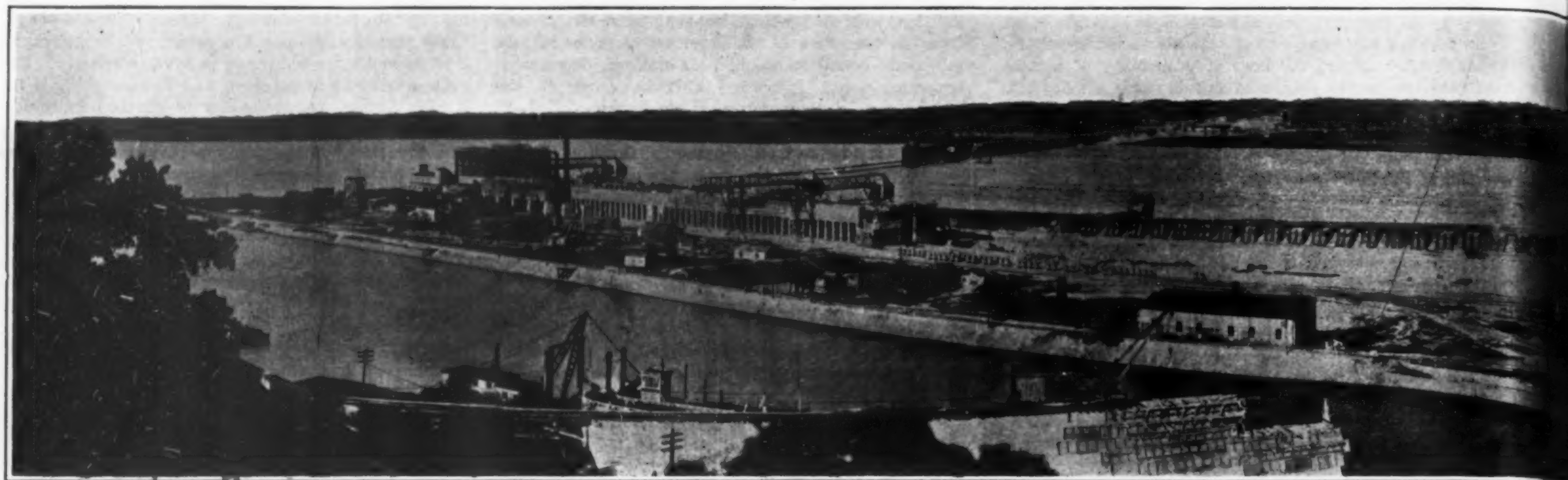
In the passing years, hydro-electric power grew into the needs of mankind, and about two decades ago Charles P. Birge, whose life was devoted to the prosaic business of selling groceries at Keokuk, had the necessary vision that was to result in damming the river for power under the new order of things. Also he had the willingness to back his vision with real money, and this created a local spirit that became irresistible. The river was a navigable stream and a dam would interfere with the government's canal, so permission of Congress had to be obtained to build it. The first bill for the purpose was introduced in Congress in 1894, by Benjamin F. Marsh, then congressman from Illinois. This proposed building a "wing" dam, utilizing merely a part of the rapids. The consent of the Iowa and Illinois legislature also had to be obtained for various measures. All of this preliminary work took years of time and was costly, but on February 9th, 1905, the bill was signed by President Roosevelt, granting a right for a full dam. This act allowed a limit of five years in which to finance and begin the work.

It is one thing to plan a $25,000,000 project and quite another to beguile the owners of big money into seeing possible dividends a long way off. The entrance to the land of capital is guarded by ogres and dragons, who are jealous of the tender morsels within. These bear the names of Caution, Money Stringency, Opposing Interest and a thousand others quite as oppressing. When Cooper with his plans and extended hand pushed into the jungle, asking men to sink millions in the bed of the Mississippi River, they not only fought him, but they were unusually deaf to arguments. In almost the last hours permitted under the Congressional act, he appeared out of the smoke and din of financial strife, triumphantly bearing negotiable bonds to build his project. He had enlisted a firm of hydraulic engineers of Boston, who have the call on unlimited capital and are said to control 175 electrical plants on the American continent. The bonds for the project were placed in this country, Canada, England, France and very largely in Germany and Belgium. The $2,000,000 worth apportioned the London market was subscribed in two hours one February day of 1911.

Work of clearing the ground was begun in January, 1910, accompanied by cheers and ringing of bells on the part of the country people of the region, who had to wait seventy-five years to greet the crystallization of an idea. It took twenty years of agitation to get the money and start the work, but it will only take two and a half years to actually accomplish the feat. To-day the dam itself is 80 per cent completed and the superstructure of the great power-house and the massive lock walls loom impressively above the crest of the growling river.

In granting a commercial corporation rights to use his river, Uncle Sam imposed stringent conditions, which are costing several millions of dollars and call for unusual engineering feats. The Nile River dam is of masonry and built for irrigation purposes, impounding a sluggish stream under the tropics. After the first estimates of the engineers it called for little more than contract work. The Roosevelt Dam across Salt River Canon in Arizona is the highest of all big dams, but it is the simple engineering feat of filling a great chasm with concrete. In the case of the Mississippi River dam, the government requires that during the navigation season the enormous natural flow of the stream shall never be interrupted.

The government's old three-lock canal will be submerged, and the company is building a single lock into the lake for the free passage of boats. In the winter time the present canal is used as a dry dock and safe harbor



General Panoramic View of the 200,000 Horse-power Hydro-electric Power Plant of the Mississippi Power Co

for river craft, and one of the things required of the company was a new dry dock. Both the lock and the dry dock, when completed, will be turned over to the government with a power plant to operate them perpetually, free of cost to the people.

One must use superlatives in describing superlative things and this great dam is both superlative and that overused word unique. At the risk of tediousness it is now necessary to plunge into a mass of figures, but it is hoped to avoid statements that the layman would not understand. The building of the dam is made possible because of the topographical and geological nature of the site. The bluffs, on both sides, rise close to the river channel, 150 to 200 feet, for a distance of about twenty miles. They are closer here than at any other point on the 2,500 miles of the river. This reduces the danger and cost from back water overflow. The bottom of the river at this point is a hard blue limestone, affording a fine footing for the dam. In hundreds of borings made by the company, this splendid foundation has been found intact to a depth of 50 feet or more, insuring that the dam will not be injured by slips or faults in the rock beneath.

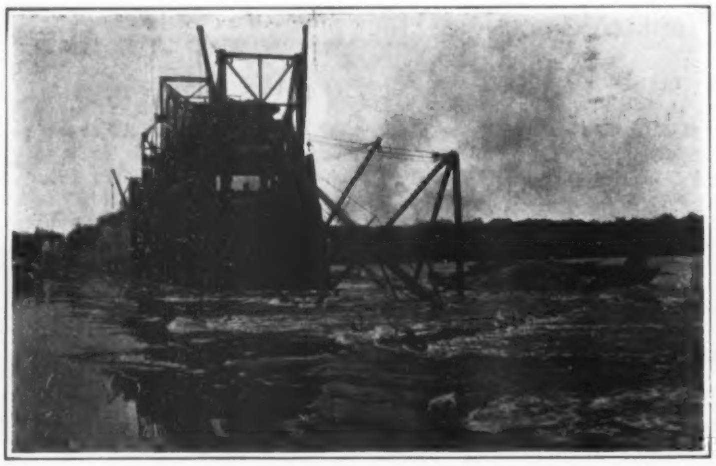
The slope of the river is steeper here than in any other part of its course, having a fall of 23 feet in twelve miles.

The engineering problems that confronted the constructing enginer had to do with the quantity of water in the river at different seasons, and it varies widely; conserving navigation by steamboats; limits of overflow cost, as determined by the property above the dam at different levels; and the construction of turbines which would yield the highest efficiency.

The thing that astonishes a thoughtful layman in going over the work is the marvelous forethought that has provided for every need and exigency that might arise. This care extends from an odd number of bolts to the pit liners that weigh a quarter of a million pounds; from a wheel-barrow to a railroad system; from a bunch of shovels to a mammoth traveling crane. The construction plant organized is the largest ever used in a work under private ownership. It cost a million dollars, invested in what may be called tools for conducting the work. They had the money to buy with and they worked on the theory that the best and most scientific was in the long run the cheapest, figuring efficiency against interest charges. The wisdom of this has long since been proved.

Here are some of the things that had to be assembled: Fifteen miles of standard gage railroad, with 16 standard gage engines; 142 cars; 3,500,000 pounds of specially built structural steel, made into eight traveling cranes, steel forms and a drawbridge; 10,000,000 feet of lumber used in coffer dams and forms for concrete work; five 10-ton derrick cars, three steam shovels and seven 10-ton stationary derricks; nine concrete mixers with a capacity of 3,500 yards in ten hours; stone crushers capable of crushing 168 carloads per day; 50 miles of iron pipe; 44 steam boilers with a capacity of 3,755 horse-power; centrifugal pumps with a capacity of 46,000,000 gallons per diem; air compressors with a capacity of compressing 6,761 cubic feet of free air per minute. Over 6,000 different articles were selected, bought and transported to the site.

The work of construction was attacked in two divisions, one on each side of the river under a superintendent. One is the Illinois division at Hamilton, Ill., the other the Iowa division at Keokuk. The Illinois division is building the dam proper, extending from the bluffs to join the

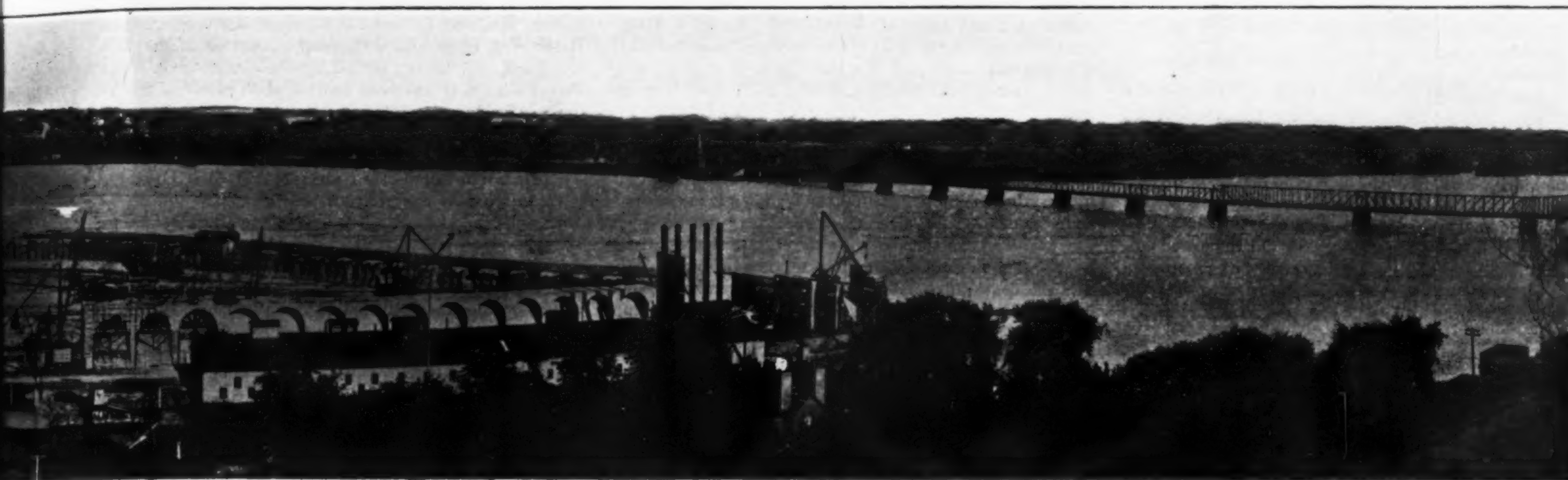


Showing the Steel Forms in Which the Piers are Molded. A Flood Drowned Out the Work Last October.

Erecting Steel Forms for Fore Bay Buttresses, as the Construction Appeared on June 6th, 1912.

These Foundations are Built for a Weight of 3,000,000 Pounds, But the Pit Liners Only Weigh 800,000 Pounds.

View of Lock from East Bull Nose, Showing Part of West Wall Completed to Full Height, June 12, 1912.



sissippi Power Company at Keokuk, Iowa. This View Shows the Works as They Appeared on June 1st, 1912.

power-house across the river. The Iowa division is building the power-house substructure and of course its turbine installation, the lock, the dry dock, the sea wall, etc. Mr. Cooper employs and directs all the workmen, and from 1,500 to 2,000 are employed.

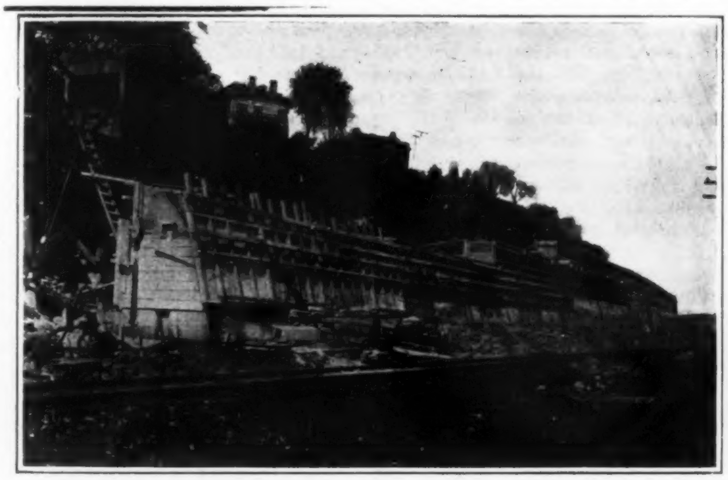
Estimates are that in the construction 650,000 cubic yards of concrete will be used, requiring an equal number of barrels of cement. The concrete mixture used is one part Portland cement, three parts sharp sand, five or six parts broken rock. The cement is made at mills located at Hannibal, Mo., transported and dumped automatically as needed at the works. The sand is pumped from the bed of the Des Moines River, two miles below, dried and steam shoveled, loaded and dumped by company machinery and cars. In all the work of construction everything is done by machinery, practically no shoveling by hand or use of pick by men being resorted to. The estimate is that 300,000 cubic yards of sand will be used, and the vastness of the work is illustrated in the statement that if all this sand were loaded into wagons at one time, the procession would extend from New York city, through Chicago, Keokuk, Omaha, Denver and the eastern boundary of Utah, over 2,000 miles.

Excellent stone was found on both sides of the river. On the Illinois side, a great quarry was opened up only 300 feet from the eastern abutment of the dam, and the stone used in making concrete for that division. The stone taken from excavating in the bottom of the river on the Iowa side had been used in concrete that went into the power-house and other work on that side. Fifteen men and a 100-ton steam shovel handle a thousand cubic yards of stone per day on the Illinois side alone.

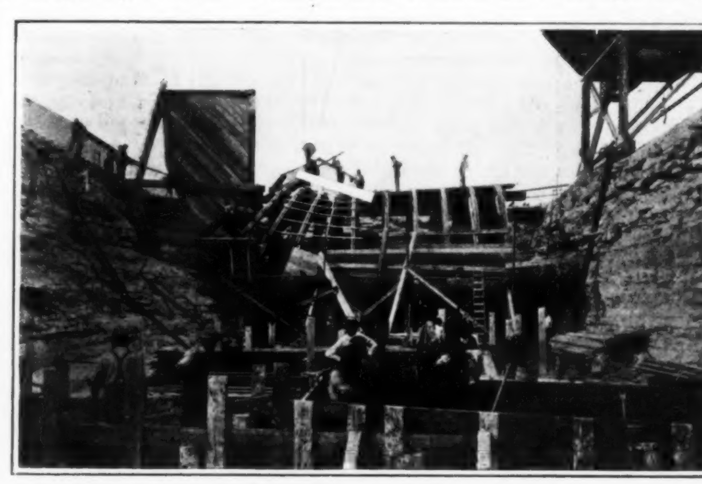
The dam and power-house substructure are monolithic concrete without reinforcement, but special parts of the construction require 7,000 tons of steel, mostly of special design. For instance there are 119 steel gates in the dam, each 11 by 32, and the large gates in the lock are 110 feet wide with a 40-foot lift. The bearing rings of the turbines each weigh 100,000 pounds. To transport the latter from the mills they had to be cut into quarters and placed a half a ring on a flat car. Special arrangements for routing had to be made to insure bridges strong enough to bear the weight and permit the passage of the immense castings.

Unwatering the bed of the river was accomplished by coffer dams. One of these is kept ahead of the dam as it crosses the river and the other surrounds the power-house and the rest of the work on the Iowa side. The coffer dam ahead of the concrete dam is 75 feet wide and the one inclosing the power-house covers 34 acres. The cribs of the coffer dams are built of logs and after being sunk to the bottom of the stream and anchored, are made water-tight. Then the water is pumped out in a few hours. The work is done by skilled cribbers who have learned their trade in the swift waters of Canada. Most of them are French-Canadians and it is a thrilling sight to watch them work since the great flood began to narrow down. The coffer dams were begun in winter, when the river was frozen over, and the cribs were built on top of the ice.

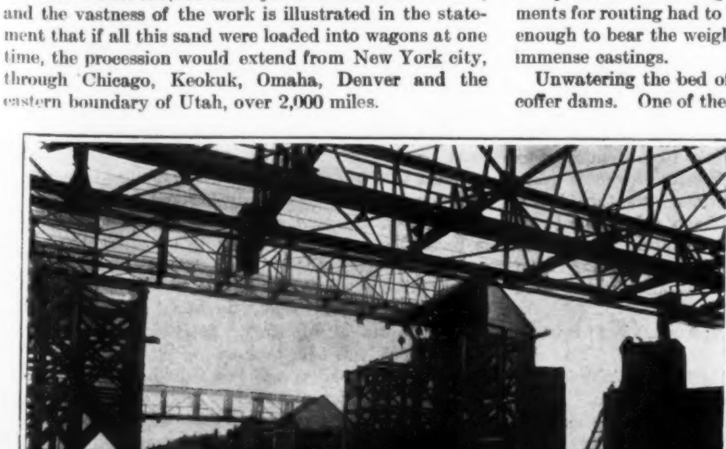
The dam proper is built out from the bluffs on the Illinois side, and locked into the rock of the hills. It is of what is known as the gravity type, its shape built to withstand all pressure upon it, by virtue of its bulk, without bracing. The structure is composed of 119 spans supporting an arch, which upholds a bridge. Between the piers, in each span, is placed a section of spillway. This leaves an opening to the top of the arch, which reminds one of an open window in a stone cathedral. This open-



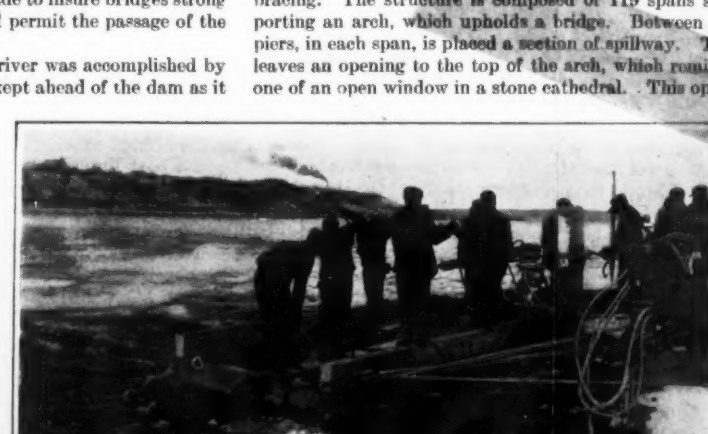
Expensive Work of Raising the Burlington Railroad Tracks to Get Them Above the High Water That the Dam Will Create.



Forms for the Immense Draft Tubes, Through Which the Waters Rush That Turn the Turbines.



View Showing the Advance of the Work on the Power House Substructure in November of Last Year.



French-Canadian Water Jacks Placing a Crib of the Coffer Dams in the Middle of the River.

ing will be filled with a steel gate when the water is shut off. It will be understood from the above that the dam also combines a bridge and spillway, unusual construction features.

The dam structure is 4,278 feet long, or four fifths of a mile. Each pier is 6 feet thick, and the distance between piers is 30 feet. The bottom of the dam is 42 feet wide and it rests on the river bed, and the top of the bridge is 29 feet wide. The top of the dam is 53 feet from its bottom. The spillway part, beneath the arches, is a solid mass of concrete, with a vertical face upstream. The top of the spillway is slightly curved and the lower face shaped to deliver the water horizontally as it runs on down stream. From the top of the structure to the spillway, on both sides, are slots 21 inches wide and 14 inches deep, in which slide the steel gates.

The use of the gates will be to keep the water above the dam at a constant level. In extreme high water they will all be open. They are built of steel truss framework faced with ⅜-inch steel plates. They will be operated by means of an electrical crane that will travel on a tramway track on top of the viaduct. The cranes will be able to entirely take out any gate and lay it on the viaduct, if need for that arises.

Five feet down in the blue limestone of the river bed is keyed the base of the dam. The eastern forty-nine spans stand in a meadow between the river bank and the bluff. The spans of the dam are cast in steel molds, exactly shaped. Eight of these are in place at a time, and as fast as the concrete hardens the form in the rear is taken down and set up ahead. On top of the dam is a three-track railroad, and as fast as a steel form is placed the cars begin hauling out concrete to be dumped into it. The dam is in this way actually helping to build itself, a cantilever traveling crane carrying the concrete at the extreme end before the track can be laid.

Here is an interesting fact in connection with the construction of the great spans. Concrete contracts and expands under heat and cold to about the same extent that steel does. That is the reason why creases are made in laying sidewalks, otherwise the concrete would crack and crumble. Heat and cold do not sink deeply into a mass of concrete, so in these great spans the problem is met in a simple way. Through the middle of each pier, from its top to the bottom of the arch, a sheet of tar paper is placed, when the concrete is cast. This acts as a cushion and in time will rot away, but will leave room for the action of the elements on the surface. Tar paper also is placed in this way between the spillway section and the piers, following the curves and vertical upstream face.

Briquettes of concrete are saved from each batch made and carefully marked as to where the entire batch was placed. These are filed, and in years to come will be carefully watched. If any defects begin to show in the samples or in the great structure itself, the chemists will know the fault and the concrete will be replaced immediately, the records showing exactly where to locate it.

As anyone, who has ever played at building dams, knows, the great difficulty is not in starting the work but in keeping from being overwhelmed as the water is impounded. This problem is being solved by the following expedient. The spillway portions between the piers are filled in gradually from the bottom upward in successive layers. The construction of the piers provides for quickly throwing a small coffer dam around any span at any time. To build the spillway sections to a full height from one end of the dam to the other, as the work progressed, would result in a current and pressure at the last spans, which would be hard to control. At the present writing, the middle of July, only 200 feet of the river remain to be inclosed. As the engineer knew would be the case, most of the water is running through the spans of the dam, but the current has set towards the west bank and goes pouring at a terrific pace through the opening that remains between the coffer dam and the northern end of the power house.

The great power-house is set out several hundred feet from the Iowa shore and between it and the shore is the present government canal. This area in time will be the forebay from which the water in the big pool created by the dam will flow to the turbines. The power-house is built with its entire length almost parallel with the river. Its dimensions are: Length, 1,718 feet; width, 132 feet, 10 inches; height from the bottom of the tailrace to the point of the roof, 177 feet, 6 inches. It is formed of two parts, substructure and superstructure. The substructure is 70 feet high to the generator floor and 78 feet high to the floor containing the transformers. The water will run through the power-house at almost right angles with the river.

This great building, a third of a mile long and higher than a city sky scraper, is set 25 feet into the solid rock. This gains additional fall to the water, which already has 25 feet drop in the rapids and 30 feet by raising the river with a dam. The substructure contains holes and chambers molded into the concrete, which are to conduct the water through the turbines to the lower levels and out at the tailrace to the natural bed of the stream. In this part of the work, wood was used for the molding forms, requiring about 5,000,000 board feet. Immense cranes have been used in this part of the work and have provided a spectacular sight for the thousands of visitors who travel from all over the Middle West to inspect its progress.

It should be understood that the water passes over the turbines much in the same way as it runs off in the sink of a washbowl, with a spiral motion. There are four intakes, branching like the fingers on a hand, mathematically calculated to a nicety. The water presses upon the wheel of the turbine with the same force at every point. The first part of the turbine accessories to be cast was the draft tube and then the scroll chamber, which incloses the wheel. The velocity of the water at the top of the draft tube will be 14 feet per second or 9 miles an hour, but before it reaches the tailrace it is reduced to 4 feet per second or less than 3 miles per hour. It is calculated that this adds 1/13 to the pressure of the water on the turbines and puts the water back into the stream with the least possible disturbance. The foundations for the turbines are built for a weight of 4,000,000 pounds each.

Now that the hydro construction is approaching completion, the electrical engineers are ready to take up their work. It should be understood that the turbines, here being placed, are as much larger than any ever built as 130 is to 30. The ultimate installation will be 30 generating units, each with a capacity of 7,500 kilowatts. It is the largest single water-power development in the world. Nearly all the water-power development in the United States is on the edge of the country, along the Pacific or Atlantic coasts. This one is the only very large development in the heart of the country. It exceeds all the combined development in any single State excepting New York, Maine and California. It is about half the total of all five companies on both sides of the international boundary at Niagara Falls.

An elaborate description of the electrical installation made probably would not satisfy the technical reader and would mystify the layman, so merely the following summary, made by the chief engineer, will be given: Francis type, special design; capacity, 10,000 horse-power; overload capacity, 13,500 horse-power; efficiency 86 per cent by Holyoke tests; 57.7 revolutions per minute; diameter at buckets, 16 feet, 2 inches; lubrication: thrust bearing by forced pressure oil and also oil-immersed roller bearing; single thrust bearing, set above water, carried rotating parts weighing 550,000 pounds. Turbine direct-connected with generator on vertical shaft 25 inches in diameter. Twenty buckets on hub. Rating based on head of 32 feet. Regulation by guide vanes at inner circle of scroll chamber actuated through a system of levers by fly-balls acting on a cylinder of compressed oil.

We now come to the great lock which is being built for the government, by which boats will be lifted up into the pool behind the dam. Engineers reckon the size of a canal by its gates and not by the length of water reservoir. The latter is a matter of building walls. The world's greatest canal lock is to be at Keokuk and not at Panama, as one naturally might suppose. In size, the Keokuk lock is the same as at Panama, but it has a greater lifting capacity. It is 110 feet wide, 400 feet long on the inside and 618 feet long on the outside. The lock gates here are 50 feet high and 110 feet wide. The lift is 40 feet, while the highest lift at Panama is but 32 feet. Why the army engineers required such big locks for the diminishing river craft is not quite clear to the writer. It might be interesting to more fully describe this portion of the big work, did space permit. Suffice it to say that when a steamboat up-stream enters the lock it will have 8 feet of water under it. The massive steel gates will close and the chamber fill with water until the boat is raised 40 feet. Then she can move, full steam, out into the open water of the big pool and travel 65 miles without crossings. It will take 10 to 15 minutes to put a boat through the one lock. At present it takes from 1 to 2 hours to put a boat through the three locks. It is hard to estimate the great value of this new order to navigation. The yearly cost of operating the present canal is $40,000, and it is estimated that the saving to the people, because of the new installation, amounts to a capitalization of $10,000,000.

Work on the proposed dry dock has not been started, as it would have interfered with navigation. This will be done next winter. The dock will stand alongside the lock and will be 150 by 463 feet in dimension. A dry dock is a chamber, filled with water, to allow the entrance of a boat, after which the water is run off. This leaves the boat high and dry on the ways or trestles. The Government will have machine shops alongside the dock.

The War Department of the United States controls the navigable rivers, and it is because of this fact that the Government engineers have supervisory charge of the dam, and of those installations that are to belong to the Government. Its engineers approve all plans, and its inspectors are constantly on the job, seeing that they are carried out.

The St. Louis branch of the Chicago, Burlington and Quincy Railroad follows the Missippi River south from Burlington, Iowa, and a considerable stretch of the present track will be inundated by the dam's pool. The Power Company has been compelled to raise the tracks for a considerable distance, at a large expenditure of money. Near the plant the track has been elevated on a mass of concrete, which is locally known as the sea wall. This stretch of concrete is 1,110 feet long.

In this region the temperature falls to as low as 25 degrees below zero and the river freezes several feet down. When the ice breaks up in the spring, floating masses of it drift by for weeks. To protect the forebay from the ice and other drift, the company will build a fender. This will be of concrete, 2,325 feet long, and extend up-stream from the upper end of the power-house. The fender will be a series of arched spans beneath the water, having a top 8 feet wide, which will be above high-water mark. The water will rush through the arches beneath. The fender will not quite reach the Iowa shore and that open space will be protected by a 300 foot floating log boom, that will be in place during the winter months and swung open during the navigation season. Besides this protection from drift, the intakes at the power-house will be screened.

Quite frequently fear has been expressed that the ice would sweep the dam away, but the engineers explain that conditions will be changed here by the structure, so that such a thing would be impossible. Near the dam the water in the pool will be very still, and in winter the currents will be running off through the power-house, many feet beneath the ice surface. Near the dam a great glacier will form that will prevent any ice jam that could reach the structure. This will gradually melt in the warm weather. However, if there are no ice jams near the dam, one can readily surmise that it will be piling up pretty high some miles above.

In the last two weeks of March of the present year, the great work at the power plant was threatened most seriously. The ice and flood conditions were the worst that anyone can recall. One day a vast sheet of ice swept down on the upper end of the coffer dam, but it withstood the impact and thereafter the lodged ice acted to protect the work, causing other descending masses to sheer off. The stage of water rose to within 3 or 4 inches of the top of the cribs, and at one time a high wind battered the waves against the top. Fortunately the engineers were able to meet the difficulties. The coffer dam, protecting the spans of the concrete dam, has been flooded a number of times since the work began, but that is of little moment, as the dam itself has always been ahead of the rest of the work, and the coffers can be pumped out in 72 hours after the water recedes.

Raising the water level above the dam will cause an overflow on both the Iowa and Illinois sides, and the company has had to face a good many problems in its settlements with the owners. A very broad policy was adopted at the outset, because the promoters realized that they had come into the community to be a part of it and build it up. Out of the 800 different persons dealt with in making settlements, for overflow rights, not half a dozen have complained of their treatment, and only three lawsuits have resulted. In addition, the company has voluntarily agreed to contribute about $100,000 in helping the counties build magnificent boulevards on the hills above the pool. The one on the Iowa shore will extend from Keokuk to Montrose and the one on the Illinois shore from Hamilton to Nauvoo, the old Mormon capital.

The power company has been buying up all the island lands in the river above the dam. Of course these will be inundated when the water rises and the growing timber would be a menace to navigation. The company has cut off over 3,000 acres of timber, some of which was made use of as lumber, but a majority was burned or given to the people living along the river.

At Green Bay, Iowa, was a tract of 20,000 acres of low land that has always been overflowed at high water, whereby its value necessarily lowered. Working with the owners of this land, the power company management is perfecting a plan by which this will be diked and reclaimed. Altogether in various ways a total of 40 square miles of the richest sort of land will be redeemed. The company had to buy up about half of the lots in the towns of Montrose, Sandusky and Galland, Iowa, which will be overflowed.

The first transmission lines will be built to St. Louis, Mo., and Burlington, Iowa. Rights of way, 100 feet wide, have been purchased, that to St. Louis being 137 miles long. The copper transmission lines are carried on steel towers set in concrete bases. It is said that the governors at the power-house will be so delicately adjusted that they will feel the starting of a street car at St. Louis.

A great many hydro-electric power installations in the past have overestimated their market, and very naturally the question arises, where will a market for such a vast output as this be found? The company already has a 99-year contract to deliver 60,000 horse-

power at St. Louis; the nearby cities of Alton, Quincy, Warsaw, Hamilton, Nauvoo, and others on the Illinois side, Hannibal, Canton, Keokuk, Burlington, and Davenport on the Missouri-Iowa side, are striving to secure manufacturing, in which cheap power is needed, to consume the balance of the company's product.

The site of the power plant is 220 miles southwest of Chicago, 180 miles east of Kansas City and 137 miles north of St. Louis. Allowing for a transmission distance as far away as Chicago, the plant is the center of population for about 4,000,570. Previous installations have shown that population has increased in the area affected to about five times the horse-power. If the rule follows in this case, the population within a radius of 50 miles of the power plant will jump to 1,500,000, which no doubt would consume all the energy that the company could produce. The great work portends a marvelous economic and social change for the region along this part of the famous Mississippi River.

The great dam contains a little less masonry than went into building the pyramid of Cheops, and the work is all being done in two and a half years. It took 100,000 men a hundred years to build the pyramid. More daring than the Simplon tunnel, more useful than the Appian Way, it should be a monument to its builder when the Chinese Wall is a memory; the industrial pivot in a region swarming with humanity.

Iron, Vanadium and Carbon in Steel*

Their Chemical and Mechanical Relations

By Professors J. O. Arnold and A. A. Read

INTRODUCTORY.

The influence of vanadium on iron and steel was discovered by one of the authors in the steel works of Sheffield University during a series of researches carried out from 1899 to 1902. The experiments were made on ingots melted by the Huntsman crucible process, and in the acid open-hearth furnace. The results were not published in any journal, but were copyrighted at Stationers' Hall. The influence of vanadium, *per se*, was not very marked on structural steel, but in the presence of chromium, nickel, and tungsten, the results were almost magical. On tool steel, *per se*, and with other elements, the results were startling. It was pointed out that as the carbide residue on dissolving the steel in dilute sulphuric acid contained nearly all the vanadium, this element probably existed in the form of a carbide, or double carbide; but so far no systematic research has been carried out to determine the exact condition in which vanadium may be present in steel. The present communication is a continuation of the author's former work, and contains an account of a number of experiments made to determine:

1. The composition of the carbides separated from a series of well-annealed steels containing various percentages of vanadium, the percentage of carbon increasing with the percentage of vanadium.
2. The mechanical properties of the alloys under static and alternating stress tests.
3. The microscopical features of the alloys.

Moissan, by heating together vanadic anhydride and sugar carbon in different proportions and at various temperatures in the electric furnace, prepared several samples of vanadium containing from 4.4 to 18.42 per cent of carbon. Moissan also found that, if the heating be prolonged, a crystalline and well-defined carbide, having the formula VC, is always obtained, which scratches quartz with ease, and is not attacked by hydrochloric or sulphuric acids.

Nicorlardot obtained the following double carbides of iron and vanadium; from steels with 0.4 per cent carbon, and 1.5 per cent vanadium, $Fe_3C.38$ (V_4C_3); from steels containing 0.8 per cent carbon and 10 per cent vanadium becomes richer in carbon as the vanadium with 9 per cent carbon and 32 per cent vanadium, $Fe_3C.74$ (V_4C_3). He also states that the carbide of vanadium becomes richer in carbon as the vanadium content of the alloy and the temperature of preparation is raised, and points out that this increasing amount of carbon found with the vanadium, as the temperature rises, confirms the results obtained by Moissan.

Guillet has examined microscopically two series of vanadium steels as forged, and has also determined their mechanical properties.

The constitution, the effect of annealing, and the mechanical properties of the two series of vanadium steels, are described by him as follows:

Constitution.

Groups.	Microstructure.	Carbon 0.20 per Cent.	Carbon 0.80 per Cent.
1	Pearlite	Vanadium < 0.7	Vanadium < 0.5
2	Pearlite and Carbide	0.7 < Vanadium < 3	0.5 < Vanadium < 7
3	Carbide	Vanadium > 3	Vanadium > 7

Annealing as a general rule softens vanadium steels. In the pearlitic steels which contain much carbide, the carbon is precipitated as graphite, but steels with the carbide show only a slight modification.

Mechanical Properties.—Pearlitic steels have a tensile strength and an elastic limit which rise rapidly with the percentage of vanadium; the elongation and reduction of area slowly decrease, while still preserving relatively high values; the brittleness does not increase; the hardness increases rapidly.

Pearlitic and carbide steels have a tensile strength and an elastic limit which are lower in proportion as the percentage of vanadium, and consequently the amount of the carbide increases; the elongation and reduction of area increase, but the resistance to shock diminishes rapidly.

Steels containing the carbide have high elongations and reductions of areas, but they are very brittle.

Paul Putz prepared a number of steels, with vanadium, increasing to 1.64 per cent, and carbon increasing to 2 per cent. The results of numerous tensile tests, and the examination of the sections of the steels of this series are described. The chemical formula for the vanadium carbide present in vanadium steels is stated to be V_2C_3, or $V_{12}C_{28}$.

Kent Smith describes his investigations on the properties of vanadium steels, and gives a summary of the effect of different quantities of vanadium on the static qualities of steel.

Giesen states that it is very difficult to judge correctly sections of vanadium steels under the microscope, since even a low vanadium content is completely dissolved by ferrite, the solution becoming saturated when the vanadium reaches 0.6 per cent. Above this quantity the vanadium unites with the pearlitic carbon to form a vanadium carbide, which comes into prominence as the vanadium in the steel increases.

Portevin, working on steels containing 0.2 per cent carbon, and from 0.6 to 0.7 per cent vanadium, and also 0.8 per cent carbon, and from 0.25 to 10 per cent vanadium, arranges the vanadium steels in three groups:

1st Group. Pearlitic steels.
2d Group. Pearlitic and double carbide steels.
3rd Group. Double carbide steels.

Hatfield, from his experiments on the influence of vanadium upon the physical properties of cast irons, comes to the following conclusions, among others—that silicon is partially prevented from crystalizing with the carbide by vanadium, and that by the presence of much of the vanadium in the carbide, the carbide is rendered more stable.

DETERMINATION OF THE CARBIDES.

The method and treatment used for separating the carbides was that described in the authors' former paper,[1] but with this modification, that the residues were dried at 100 deg. Cent. in a current of hydrogen, the tube being pumped out from time to time. The steels dissolved quite readily, and with each member of the series vanadium was found in the hydrochloric acid solutions; but in most cases it was quite unnecessary to test for vanadium, as the electrolyte was distinctly blue to dark-blue in color.

The carbides obtained from Nos. 1315 and 1316, containing 0.71 and 2.32 per cent of vanadium, were dark-gray; and from Nos. 1309, 1310, and 1312, containing 5.84, 10.30, and 13.45 per cent of vanadium, slate-gray in color.

The analysis of the carbides were carried out as follows: The porcelain boat containing the dried carbide was weighed. About one half of the carbide was carefully removed and put on one side for the determination of iron and vanadium. The boat was again weighed, the carbide well mixed with pure manganese dioxide, and the carbon estimated by direct combustion. The remaining portion of the carbide was intimately mixed with sodium carbonate and a small quantity of sodium peroxide in a platinum basin, and heated in a muffle furnace. When cold, the mass was repeatedly boiled with water and filtered. The vanadium in the filtrate was estimated by reducing with sulphurous acid and titrating with a standard solution of potassium permanganate. The residue on the filter paper was dissolved in hydrochloric acid and made up to a known volume. The iron was then estimated by the usual volumetric process, using a standard solution of potassium dichromate for the titration. The very small quantity of vanadium found in the iron solution was determined by the hydrogen peroxide color test. The results are given in Table II.

TABLE II.

No. of Steel.	Carbon per Cent.	Vanadium per Cent.	Amperes.	Volts at Terminals.	Time in Acid.	Grammes Dissolved.	Weight of Dry Residue.	Percentage of Total Carbon Obtained with Carbide Residue.	Analysis of Carbon.			Corresponding to the Formula.	Theory.		
									Carbon per Cent.	Iron per Cent.	Vanadium per Cent.		Carbon per Cent.	Iron per Cent.	Vanadium per Cent.
					hrs.										
1315	0.60	0.71	0.5	0.6 to 1.5	12	8.920	0.6753	95.77	7.61	83.71	8.68	11 Fe_3C + V_4C_3	7.57	83.24	9.19
1315	0.60	0.71	0.5	0.6 ,, 1.5	12	8.926	0.6847	96.98	7.66	83.69	8.65				
1315	0.60	0.71	0.5	0.6 ,, 1.5	11	8.260	0.6154	92.71	7.49	83.27	9.24				
1316	0.63	2.32	0.5	0.7 ,, 1.2	11	8.064	0.4346	88.10	10.66	54.60	34.74	2 Fe_3C + V_4C_3	10.00	56.00	34.00
1316	0.63	2.32	0.5	0.7 ,, 1.2	11	8.053	0.4148	82.80	10.44	54.71	34.85				
1316	0.63	2.32	0.55	0.7 ,, 1.2	10	7.630	0.4189	91.20	10.63	53.30	36.07				
1309	0.93	5.84	0.5	0.8 ,, 1.3	12	8.625	0.5066*	99.15	15.94	0.54	83.52	V_4C_3	15.00	..	85.00
1309	0.93	5.84	0.5	0.8 ,, 1.3	12	8.512	0.4973*	98.19	15.94	0.47	83.59				
1309	0.93	5.84	0.5	0.8 ,, 1.3	12	8.313	0.4890	97.63	16.05	0.83	83.12				
1310	1.07	10.30	0.5	0.8 ,, 1.4	12	8.168	0.5952	96.76	15.03	1.04	83.93				
1310	1.07	10.30	0.5	0.8 ,, 1.4	12	8.160	0.5732*	95.22	15.00	0.63	84.37				
1312	1.10	13.45	0.5	0.8 ,, 1.6	12	8.303	0.6757*	99.78	14.12	0.82	85.06				
1312	1.10	13.45	0.5	0.8 ,, 1.6	12	8.571	0.7267	99.06	13.76	1.27	84.97				

* These carbide residues were boiled for 1 hour with dilute sulphuric acid (1 of acid to 10 of water), then washed, treated, and dried in the usual way.

METHOD OF MANUFACTURE OF THE AUTHORS' STEELS.

The alloys were made by the coke crucible process in Sheffield white clay pots from Swedish bar iron, American washed iron, and 38 per cent ferro-vanadium; 0.05 per cent of metallic aluminium was added to each a few minutes before teeming. The ingots, 2¾ inches square, and each weighing 40 pounds, were cogged and hammered into bars 1⅛ inch round. The bars were heated to about 950 deg. Cent. for six hours, and were allowed to cool during an additional twelve hours.

CHEMICAL COMPOSITIONS OF AUTHORS' SERIES.

The analyses of the steels were made on the last turnings from the carbide bars. The results are given in Table I.

TABLE I.

No. of Steel.	Carbon per Cent.	Vanadium per Cent.	Silicon per Cent.	Phosphorus per Cent.	Manganese per Cent.	Sulphur per Cent.	Aluminium per Cent.
1315	0.60	0.71	0.05	0.01	0.06	0.04 or under	Under 0.01
1316	0.63	2.32	0.09	0.01	0.07		
1309	0.93	5.84	0.21	0.02	0.11		
1310	1.07	10.30	0.32	0.05	0.12		
1312	1.10	13.45	0.47	0.03	0.12		

A consideration of the results in the foregoing table indicates that in most cases practically the total amount of carbon in the steel is obtained as carbide. The

Fig.1.

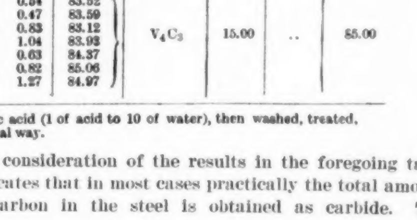
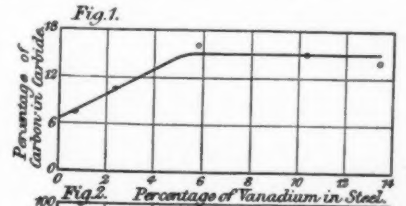


Fig.2. *Percentage of Vanadium in Steel.*



Percentage of Vanadium in Steel.

[1] Journal of the Iron and Steel Institute, 1911, No. 1, page 249.

* Paper read before the Iron and Steel Institute, May 9th, 1912, and published in *Engineering*.

Fig. 3.—Micrograph No. 1.
Carbon, 0.60 per cent; vanadium, 0.71 per cent.
Magnified 180 diameters.

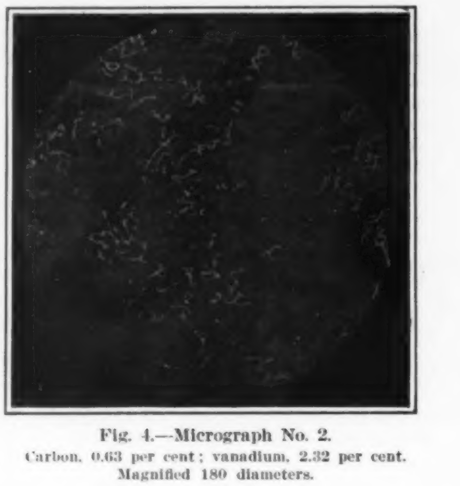


Fig. 4.—Micrograph No. 2.
Carbon, 0.63 per cent; vanadium, 2.32 per cent.
Magnified 180 diameters.

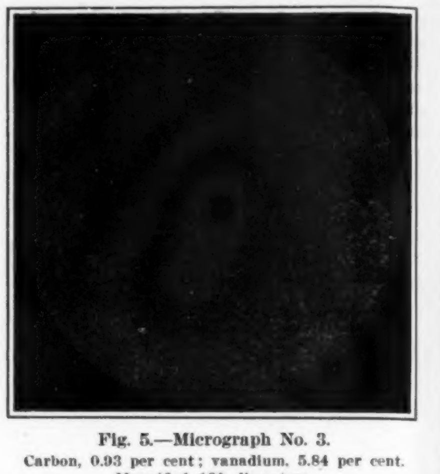


Fig. 5.—Micrograph No. 3.
Carbon, 0.93 per cent; vanadium, 5.84 per cent.
Magnified 180 diameters.

slightly lower results are not due to any appreciable decomposition of the carbide during the electrolytic run, but are accounted for by a slight roughness of the bars which prevented the last traces of carbide being obtained.

The results given in Table II also show that vanadium replaces iron in the carbide, even when the steel contains only such a small quantity as 0.71 per cent of vanadium, with the formation of a mechanical mixture of the carbides of iron and vanadium corresponding to the formula $11\ Fe_3C + V_4C_3$.

As the vanadium in the steel increases, more vanadium is found in the carbide, and with the next member of the series, containing 2.32 per cent of vanadium, the carbide is represented by the formula $2\ Fe_3C + V_4C_3$.

Coming to the remaining three steels of the series, with 5.84, 10.30, and 13.45 per cent of vanadium, in each case practically the whole of the iron has been replaced by vanadium, and most probably a definite carbide of vanadium is obtained corresponding to the formula V_4C_3.[2]

These results are shown more clearly in Figs. 1 and 2. It will also be noticed (Table II) that it is possible to reduce still further this small quantity of iron found with the vanadium by digesting the carbide residues with hot dilute sulphuric acid.

TURNING CHARACTERISTICS OF THE ALLOYS.

The report of Mr. J. Harrison, laboratory engineer in the Metallurgical Department of Sheffield University, on the behavior of the bars in the lathe is embodied in the following table, the word "tough" having reference to the capability of the material to curl off in spirals during the turning operations:

Steel No. A.	Carbon per Cent.	Vanadium per Cent.	Turning Report.
1315	0.60	0.71	Tough.
1316	0.63	2.32	"
1309	0.93	5.84	" and slightly hard.
1310	1.07	10.30	" "
1312	1.10	13.45	" " hard.

MECHANICAL PROPERTIES.

The static results are embodied in the following table, the test-pieces being 2 inches parallel and 0.564 inch in diameter:

Table of Tensile Tests.

Steel No. A.	Yield-Point.	Maximum Stress.	Elongation	Reduction of Area
	tons per sq. in.	tons per sq. in.	per cent.	per cent.
1315	12	35.9	22.0	41.4
1316	14	35.0	24.5	52.0
1309	17	33.4	25.0	53.2
1310	15	33.7	23.0	31.5
1312	18	37.0	10.0	9.7

Since 1309 contains 0.93 p.c. of carbon, its test result is remarkable.

[2] It is theoretically possible that this may be a mixture of vanadium carbides.

ALTERNATING STRESS TESTS.

The dynamic tests obtained under standard conditions of the Arnold machine are tabulated as follows:

Table of Alternating Tests.

Steel No A.	Alternations Endured.		
	First Test.	Second Test.	Mean.
1315	126	112	119
1316	162	220	191
1309	144	126	135
1310	94	144	119
1312	8	22	15

The poor dynamic properties of the series exemplify the evil influence of drastic annealing on vanadium steels.

MICROGRAPHIC ANALYSIS.

The microscopical examination of the steels leads the authors to announce provisionally the discovery of two new constituents: 1. Vanadium pearlite; 2. Vanadium cementite, V_4C_3.

1. *Vanadium Pearlite.*

This constituent seems incapable of segregating into the laminated variety, and presents itself only in the troostitic and sorbitic forms. Its saturation point seems considerably higher than that of iron pearlite, but this point requires further research.

2. *Vanadium Cementite.*

This constituent (a decomposition product of vanadium pearlite) is not nearly so mobile as Fe_3C, and consequently segregates into relatively minute irregular masses very much smaller than massive iron cementite.

The micrographic analysis has proved, almost beyond doubt, that there is no double carbide of iron and vanadium, since when Fe_3C and V_4C_3 are together in a well-annealed steel, the former has segregated as usual, while the latter has remained distributed in its pearlite in the troostitic or sorbitic form.

Micrograph No. 1.—In this structure was found (*a*) a pale ground mass of slightly vanadiferous ferrite; (*b*) a few areas of laminated iron pearlite; (*c*) the Fe_3C of decomposed laminated iron pearlite in the form of cell walls and irregular masses; (*d*) dark etching troostitic[3] vanadium pearlite; (*e*) less-dark etching areas of sorbitic[4] vanadium pearlite. This section contains 0.6 per cent of carbon and 0.71 per cent of vanadium (Fig. 3).

[3] The term "troostitic" has reference to pearlite, in which the carbide is in a state of division so fine as to be beyond the range of microscopic vision.

[4] The term "sorbitic," as used in this paper, has reference to pearlite, in which the carbide, although in a fine state of division, is nevertheless within the range of microscopic vision.

Micrograph No. 2.—This steel presents a very confused structure, in which vanadiferous ferrite and vanadium pearlite in both the troostitic and sorbitic forms have segregated very imperfectly in spite of the twelve hours' cooling. The only well-defined constituent is the iron cementite which has readily segregated in meshes and masses, but is distinctly less in quantity than that in Micrograph No. 1. The steel represented in Micrograph No. 2 contains 0.63 per cent carbon and 2.32 per cent vanadium (Fig. 4).

Micrograph No. 3.—This section consists largely of sorbitic vanadium pearlite, overlaid, however, by irregular meshes, apparently of vanadiferous ferrite. In other words, the steel is not saturated. It contains 0.93 per cent carbon and 5.84 per cent vanadium (Fig. 5).

Micrograph No. 4.—This contains 1.10 per cent carbon and 13.45 per cent vanadium. It is almost identical in structure with steel No. 1310, which contains 1.07 per cent carbon and 10.30 per cent vanadium. The ground mass is vanadiferous ferrite, over which are scattered small segregated irregular masses of vanadium cementite, V_4C_3. Each particle is environed by a somewhat dark border of probably sorbitic vanadium pearlite, and small patches and streaks of this constituent are also scattered over the field. The mobility or segregative capacity of V_4C_3 obviously increases with the percentage of vanadium present in the ferrite (Fig. 6).

A New Industry for Malaysia.—It has been proposed to start in Malaysia a small export trade in shark's liver oil. This oil is refined in Europe and sold as cod liver oil. There are several species of these sharks, and they ordinarily run from 7 to 15 feet in length, the girth being of nearly the same dimensions. They are speared in large numbers by people skilled in catching them. They are found in pairs, and the harpooners try to kill the male first, in which case they are able also to spear the female as it does not desert its mate. The liver of an 11-foot shark gives about 5 gallons of oil. The oil brings $73 a ton.—*Consular Report.*

Volatitity of Platinum.—Sir William Crookes has brought before the Royal Society the results of some experiments which indicate that platinum is volatile below its melting point. At 1,300 deg. Cent. a platinum crucible lost 0.245 per cent of its weight. Palladium lost 0.745 per cent and iridium 7 per cent after 2 hours exposure. At 900 deg. Cent. platinum lost no weight, but palladium lost 0.09 per cent in 10 hours and iridium 0.09 per cent in 20 hours. In a vacuum at 1,300 degrees iridium volatilized to an appreciable extent, with condensation in the cooler portion of the quartz tube.

Fig. 6.—Micrograph No. 4.
Carbon, 1.10 per cent; vanadium, 13.45 per cent.
Magnified 180 diameters.

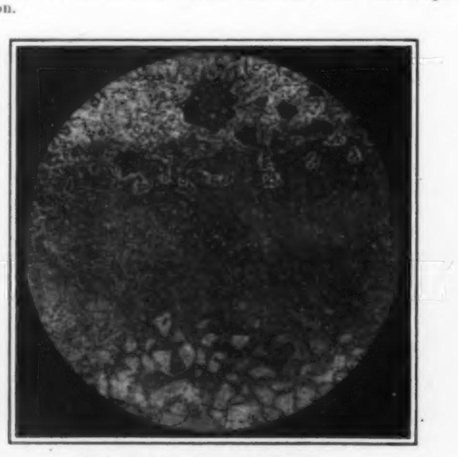


Fig. 7.—Micrograph No. 5.
Carbon, 1.10 per cent; vanadium, 13.45 per cent. Quenched from 1,400 deg. Cent. Magnified 180 diameters.

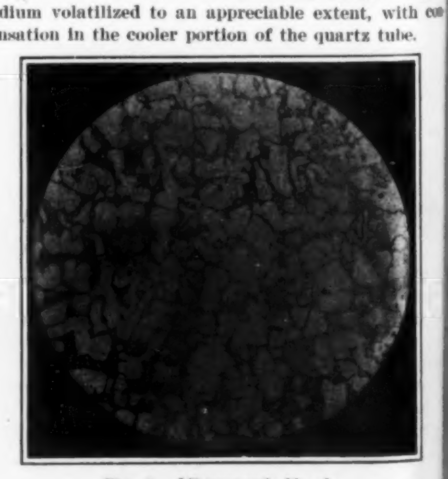


Fig. 8.—Micrograph No. 6.
Carbon, 1.10 per cent; vanadium, 13.45 per cent. Full field of lower area shown in Micrograph No. 5. 180 diameters.

The Cryogenic Laboratory at Leyden*

The World's Center for Low Temperature Research

By G. Bresch

THE most remarkable plant for the continuous production of low temperatures is that of the laboratory directed by M. Kamerlingh Onnes, professor at the University of Leyden.

This installation has required on the part of this learned physicist more than twenty-five years' of persevering efforts such as only those who have in some sort personally conducted research work can comprehend.

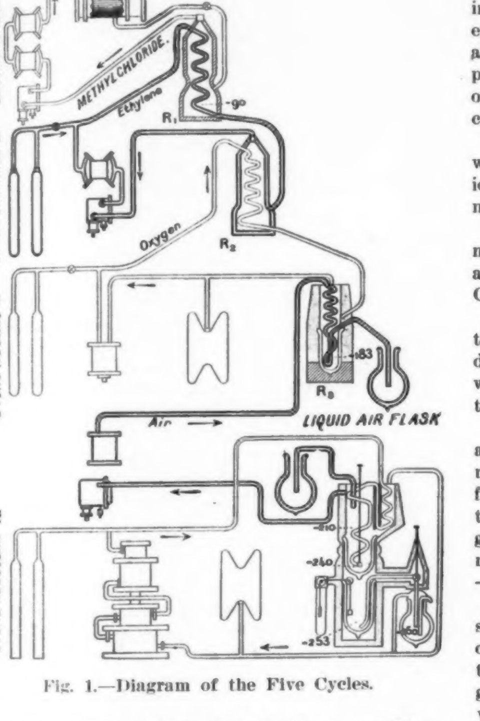


Fig. 1.—Diagram of the Five Cycles.

In consequence of these efforts it is now possible to study at temperatures down to —270 deg. Cent. the most diverse phenomena, electric or magnetic. Interest in such researches was thus predicted by M. d'Arsonval in the discourse pronounced by him October 12th, 1908, in closing the first International Congress of Refrigeration at Paris: "The intimate constitution of matter and the nature of electricity may be revealed to us by studying them in the neighborhood of absolute zero, —273 deg. Cent. The discoveries led up to by the labors of Curie, J. J. Thomson and Rutherford show us to-day the atom as a solar system in miniature. It is constituted by the fantastic rotation of electric corpuscles, holding stored within them, in spite of their minute size, live forces many million times superior in energy to the most violent chemical reactions. . . ."

Thus, in the atom of hydrogen, i. e., in a thing a thousand times less heavy than the billionth of a billionth of a milligramme, there are a thousand or so of these corpuscles called electrons, charged with negative electricity and gravitating around a nucleus charged with positive electricity. These electrons are separated from each other by distances comparable, considering their size, to those of the planets in the solar system; they revolve about each other and about the nucleus with an extreme rapidity, many millions of billions of revolutions per second; of this extraordinary activity is born the formidable energy inclosed within the invisible particle of dust we call an atom. Lodge tries to give an idea of this by saying that in a gramme of hydrogen there is enough energy to lift the entire British fleet to the top of the highest peak in Scotland.

We can, by setting in action powerful magnetic fields, change the orbits of the electrons, and thus affect these marvelous corpuscles, and by modifying the solar system of the atom, obtain affirmation of the preceding conclusions.

The labors of M. Kamerlingh Onnes on the conductivity of metals at very low temperatures suggest the means of obtaining powerful magnetic fields by passing electric currents of great intensity into small coils at a sufficiently low temperature.

Thus the study of matter at temperatures in the vicinity of —270 deg. Cent. may elucidate the mystery of its ultimate constitution. This is a supremely fascinating question discussed with passionate zest in all scientific circles.

The Production of Low Temperatures at Leyden.—The laboratory at Leyden is devoted to the pursuit of pure science. The aim is to establish and maintain any temperature below zero Cent., to keep at this constant temperature as long as may be desired apparatus of any ordinary dimension.

It is not possible to obtain at one blow very low temperatures; it is necessary to proceed by stages, producing successive falls in temperature; each fall is due to the employ of a suitable gas, which liquefies, then evaporates, and liquefies anew in passing through an appropriate cycle. The *ensemble* of cycles of the circulation of the gases constitutes what is called a *cascade* in the cryogenic laboratory.

To realize these different cycles M. Kamerlingh Onnes was obliged to become in turn a coppersmith, a mechanician, a fitter, a plumber, and to create all the parts of the machines and utensils of which he had need.

The Leyden cascade comprises five cycles which permit by suitable variations of pressure the production of any temperature between 0 deg. Cent. and —272 deg. Cent.

The cycle of methyl chloride leads to —90 degrees; that of ethylene to —160 degrees; we arrive at —270 degrees, thanks to the cycle of oxygen, at —259 degrees with hydrogen, and finally the cycle of helium permits the descent to —272 degrees.

The first cycle, in which methyl chloride is the cooling agent, reduces the temperature to —90 deg. Cent.; in the next cycle, in which ethylene is used, the temperature falls to —160 degrees; by means of liquid oxygen, the temperature is, in the third cycle, reduced to —210 degrees; hydrogen gives —259 degrees, and lastly, by means of helium, the excessively low temperature of —272 degrees of 1 degree absolute is reached.

Fig. 2 gives a general view of the plants and Fig. 1 shows diagrammatically the arrangement of the five cycles. The liquid methyl chloride is led into a receptacle R_1; here it is made to boil under reduced pressure, giving a temperature of —90 deg. Cent.; the cooled vapors are taken up again by a pump, liquefied anew, and returned to the receptacle R_1. The same methyl chloride circulates indefinitely in the cycle, passing alternately from liquid to gaseous estate.

In the second cycle the vapors of ethylene, compressed, then cooled by the vapor of methyl chloride in a heat exchanger, liquefy in the receptacle R_2. In the third cycle oxygen is liquefied by the aid of ethylene evaporating *in vacuo*. All the cycles working with pure gases are closed with the greatest care. The cooling flask R_3, with liquid oxygen, is used in preparing liquid air.

Hydrogen circulates in the fourth cycle. Cooled by liquid air to about —210 deg. Cent., it is liquefied by allowing it to expand.

The apparatus contains a number of fine stopcocks and narrow capillary tubes through which the hydrogen has to pass. If only a few cubic centimeters of air should become admixed to several hundreds of liters of hydrogen circulating in the apparatus, such air, solidified by the intense cold, will suffice to choke the tubes and cocks. Hence continuous action is possible only with extremely pure hydrogen.

Finally in a fifth cycle helium liquefies and vaporizes. It may be mentioned that 200 liters of helium alternately can be compressed at 100 atmospheres, and retain an almost absolute purity. This purity is necessary even more than in the case of hydrogen because of the extreme fineness of the capillary tubes. The helium employed contains less than 1/10,000 of foreign gas (purity "controlled" by the spectroscope).

Fig. 2 represents a part of the cascade of the cryogenic laboratory. The numerous accessories seen in the figure are all necessary to meet the manifold exigencies of the measures of precision.

Fig. 3 shows the refrigerants of the cycles of methyl chloride, ethylene and oxygen.

Putting the Different Cycles in Operation.—Nothing demands more methodic treatment than the setting in operation of the different cycles. When all the material is ready, M. Kamerlingh Onnes, standing near the principal apparatus, like the commander of a ship, gives his orders to the observers or mechanicians placed at the head of the different cycles. This is because the various apparatus must begin to act one after the other in a precisely determined order. Little by little each one "comes to life." . . . Finally the helium cycle begins to act in its turn; the experiments may be begun. The following schedule will give an idea of the time involved: 9:15, the first cycle is started; 10:00, the condensation of the ethylene in the second cycle is begun; 10:37, liquid ethylene has accumulated in the ebullition flask; 11:50, the maximum quantity of liquid ethylene is obtained, the tension of the vapor is 150 millimeters; the temperature becomes lower; 12:09, the tension of the boiling ethylene is 70 millimeters; 12:15, compressed oxygen is introduced into the spiral of the third cycle; 12:44, a liquid jet is obtained in the oxygen container; 1:32, the bath of liquid oxygen is obtained at atmospheric pressure; 2:10, the bath is in normal condition for working; 4:45, the process is completed.

With his extended experience, M. Kamerlingh Onnes now considers it relatively easy to obtain 60 deg. Cent. of liquid helium in a few hours. This helium, evaporated under the pressure of 0.04 millimeter of mercury, has given the temperature of 272 —deg. Cent. This is the lowest temperature ever obtained up to the present time.

Some Studies Made in the Cryogenic Laboratory.—Scientists of every land may study the most diverse phenomena at Leyden, where they are received with the greatest hospitality. The following are some of the studies carried out there:

a. The electric conductivity of metals at low temperatures.

b. The temporary suspension of life in certain seeds.

M. P. Becquerel has investigated whether at very low temperatures the life of grains may be suspended for any definite period of time, and resumed later at the will of the experimenter.

His experiments have been carried out with seeds of mustard, lucerne and wheat. The integument of the grain was perforated in such manner as to make it more permeable. These grains, dried in a vacuum for six months, then placed at Leyden in liquid air for three months, were finally kept for 77 hours at —253 deg. Cent. (by the aid of a bath of liquid hydrogen).

On their return to Paris, the grain placed on absorbent cotton at 28 deg. Cent. germinated at the end of a few days. The difference could be observed between this germination and that under ordinary conditions.

Thus the law of the continuity of vital phenomena so

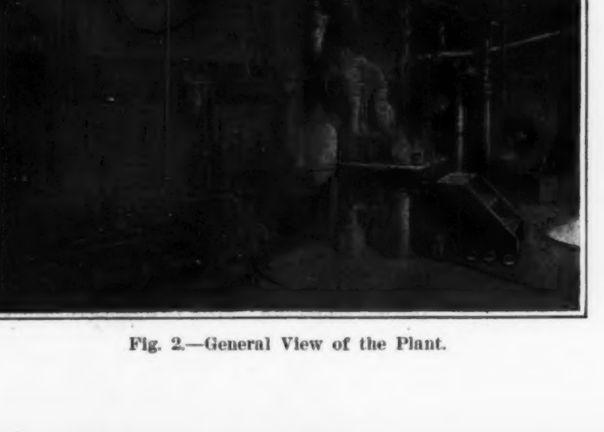


Fig. 2.—General View of the Plant.

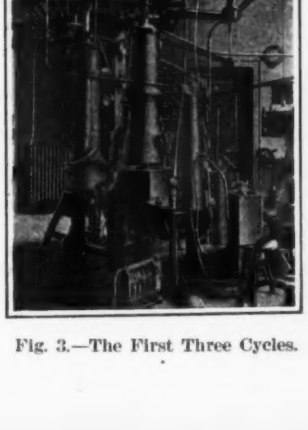


Fig. 3.—The First Three Cycles.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *La Nature*.

often invoked by physiologists seems at fault. According to this law life is a succession of uninterrupted phenomena which can in no case be arrested without fatal result, and which has been transmitted from generation to generation since its first appearance on the earth, without the slightest discontinuity.

M. Becquerel's experiments do not agree with this supposition. As M. Armand Gautier has frequently said, seeds, or even the lower animals, may often be considered as machines, dead for the time being, but ready to function—watches put together accurately and needing only to be wound up to start running. These machines, these "timepieces," will not move until the proper conditions produce the required "winding."

c. The specific heats of solids at low temperatures.—From Nernst's work we know that the specific heats of various solids rapidly diminish as the absolute temperature approaches zero.

The Production of Ethyl Alcohol from Waste Products*

By Alcan Hirsch

The first synthesis of ethyl alcohol was made about 1826, by Hennel, utilizing the reaction of ethylene and sulphuric acid to form sulphovinic acid which, upon heating with an additional quantity of sulphuric acid, yields alcohol. Berthelot improved this process by synthesizing ethylene from its elements *via* acetylene, and by making a more complete conversion of ethylene into sulphovinic acid.

The one source of the alcohol is the action of the zymase of yeast upon glucose and other fermentable sugars. The sources of the fermentable sugars may be grouped into two classes:

1. The products of the hydrolysis of starch and allied substances by means of an amylase.

2. Solutions of sugars obtained directly from fruits and plants and from the non-crystallizable by-products of sugar-works—such as molasses.

The most economical source of starch in our country is probably Indian corn, costing about $21 per ton. One ton of corn gives about ninety gallons of 94 per cent alcohol. About two gallons of raw molasses produce one gallon of 94 per cent alcohol, and this raw material costs about 21 cents per gallon of 94 per cent alcohol. The costs of the distillation of the mashes and the rectification and purification of alcohol cannot be entered into here, but the approximate cost of 95 per cent alcohol (190 proof) to the consumer may be taken as about 50 cents per gallon, exclusive of taxation.

Within the last two or three years, two new commercial processes for the production of alcohol have been put in operation on a comparatively large scale. The purpose of this article is to present and discuss briefly from a chemical engineering standpoint these two processes: namely, the production of alcohol from sulphite cellulose waste lyes, and the production of alcohol from sawdust.

I. ALCOHOL FROM SULPHITE LYES.

In the sulphite process for the production of pulp, for every ton of cellulose there are about ten tons of sulphite lyes (T. H. Norton, *U. S. Cons. Rep.*, November, 1911) which contain one-half the weight of the wood originally introduced into the boilers. Among the substances present are: dextrose and other sugars, xylose, acetic acid, tannic acid, nitrogen compounds, methyl alcohol, resins, etc., and calcium lignin-sulfonate, the chief product of the reaction. Most of the sugars in these lyes are fermentable and constitute about 1 per cent of the lyes, the yield of alcohol being from fifteen to seventeen and one half gallons per ton of cellulose (C. G. Schwalbe, *Z. angew. Chem.*, 23, 1537, 1910).

Recently in Sweden two industrial processes have been developed, that of Ekström (P. G. Ekstrom, Eng. Pat. 6714, March 17th, 1910) at Skutskär and that of Wallin at Forss. These processes are practically identical, differing only in the neutralization of the acid. The former uses lime, chalk, etc., and the latter waste causticization sludge. The general scheme is as follows: The lyes are first neutralized in large vats, then cooled in towers and aerated. In a mill producing ten tons of cellulose per twenty-four hours the volume of the lyes to be treated is about nine thousand gallons per day. A yeast nutrient, malt extract or dead yeast is added to the cool, neutral liquid which is transferred to the fermentation vats. After fermentation (which takes three days or more) the yeast is separated and the liquid distilled in a continuous still. The percentage of alcohol is very low and considerably more steam is used in the distillation than is required with mash from molasses which usually contains about 7 per cent alcohol by volume. The alcohol obtained is already denatured as it contains considerable methyl alcohol (from the unfermented lyes), furfurol, aldehydes, and sometimes acetone, but is practically free from terpenes.

The above process with a few minor changes is being worked on a large scale at several places in Sweden. The experimental plant at Skutskär began operations on May 24th, 1909, using waste lyes from a 5,000-ton cellulose plant. In March, 1910, 560 gallons of "normal strength" alcohol were produced per 24 hours. The total for the month was about 13,000 gallons. The process yields about 6 gallons of absolute alcohol for 1,000 gallons lye, and about 14 gallons for every ton of cellulose.

As the alcohol produced from waste lyes is denatured, its chief uses will necessarily be for heating and other industrial purposes. The industrial prospects of this process depend on the cost of production, condition of taxation and capacity of the market. Estimates of the cost of production for a mill producing 340,000 gallons per annum place the cost at about $9.50 per 100 gallons. In Sweden the tax per gallon increases with the output, so that for an annual production of 340,000 gallons, the cost of production including the tax is about $15.50 per 100 gallons. In Germany excise regulations penalize new distilleries so that in addition to the cost of production, sulphite spirit would be subject to a tax of about $17 per 100 gallons. Regarding the capacity of the market, in Sweden during the fiscal year 1908-1909 the total production of alcohol was about 5,800,000 gallons (absolute) and the imports were about 310,000 gallons. The sulphite lye mill at Larkudden is reported as having produced spirit during the year 1910 at the rate of 157,000 gallons per annum, and the annual rate of production at the present time is estimated at 250,000-400,000 gallons. The pulp mills of Sweden can produce 6,500,000 gallons of absolute alcohol per annum. It must be remembered that the present method of production from grain is always intimately connected with the agricultural industries of the country, and therefore will not be easily displaced. Also, while under special conditions (especially low taxation) the sulphite process can be worked at a profit, yet it does not solve the problem of the disposal of the waste lyes, as only about 1 per cent of the total weight of lyes is converted into alcohol. In fact, on account of the presence of dead yeast, etc., the problem of the disposal of the lyes may be aggravated by the use of this process.

II. ALCOHOL FROM SAWDUST.

The cost of raw material is always of great importance in any industry. While Indian corn costs about $21 per ton, sawdust in the vicinity of a large mill where it is a by-product can be bought at a cost of 30 to 50 cents a ton including handling and transportation (short distances). One ton of sawdust calculated to the dry basis can yield 20 gallons of 94 per cent alcohol, which makes the cost of this raw material 2½ cents per gallon 94 per cent alcohol, as against 24 cents for Indian corn.

For nearly one hundred years it has been known to chemists that fermentable sugars can be produced from sawdust. The reaction is usually spoken of as being very simple, all that is necessary being to add a molecule of water to the cellulose. This hydrolysis is probably as complex as it is baffling. The unknown composition of those polysaccharides which we call cellulose and the very different results obtained on hydrolysis under slightly different conditions of catalyzer, temperature and pressure indicate that somewhat intricate reactions occur, the complete chemistry of which is not known at the present time. A very large number of patents have been granted on this reaction, the main differences being in method of manipulation and the catalyzing acid used. Sulphuric acid has been used in many cases, but the subsequent removal of this acid has proved a serious stumbling-block. No process that was capable of commercial application had been devised until the year 1900 when Dr. Alexander Classen was granted his first patent. The more important English patents granted him are: No. 258, January 4th, 1900; No. 4,199, February 27th, 1901; No. 12,588, June 20th, 1901. "Process claimed consists in boiling cellulose in a closed vessel at a temperature of 120 to 145 deg. Cent. with a solution containing sulphurous and sulphuric acids or sulphurous and hydrochloric acids. A solution of 2 per cent or more of sulphurous acid and 0.2 per cent sulphuric acid is mentioned. The sulphuric acid may be conveniently formed in the boiler by admission of air or other suitable oxidizing agent. In this way concentrations of 10 per cent sugar may be obtained, 80 to 90 per cent of which is fermentable. Conversion is complete in 15 minutes."

An experimental plant using this process was erected at Aachen and a similar plant on a larger scale was built at Highland Park near Chicago. The results were satisfactory so that it was decided to build a commercial scale plant at Hattiesburg, Miss. The capacity of the conversion cylinder was two tons. After the conversion the acid was neutralized, cleared by subsidence, pumped into large vats and fermented by yeast and then distilled. From a commercial viewpoint this plant was a complete failure. From a chemical engineering standpoint it is an excellent example of a process which fell just short of success. The reasons given for the failure are: 1. Length of time required for conversion: 1½ to 2 tons requiring 4 to 6 hours. 2. Prolonged action produces gums and caramels and makes extraction of the sugar tedious and expensive. 3. Large quantity of acid required. 4. Lining difficulties, especially with lead linings.

Two chemical engineers, Ewen and Tomlinson, studied and undertook to improve this process. Their patent U. S. 938,308, 1909, describes their process. The converter used by Classen was about 30 feet in length and had a diameter of 3 feet, whereas in the Ewen and Tomlinson process the digester is much shorter, usually being about 12 feet in length and 8 feet in diameter. The latter line their converter with fire-brick instead of using the troublesome lead lining. The operation seems to be fairly simple. Sulphur dioxide gas to the extent of 1 per cent of the weight of the wood is introduced into the cylinder and live steam is turned on until a pressure of 100 pounds is obtained. The steam is then turned off and the cylinder slowly revolved for 40 to 45 minutes, the temperature and pressure being kept constant. The total time of conversion is about 1 hour as against 4 to 6 hours in the old process. In operating this process it is important to raise the temperature as quickly as possible to the "critical point" which is defined as "that temperature above which the production of unfermentable substances and the destruction of the sugars become excessive and lie between 135 and 163 deg. Cent." After extraction, the converted lyes have a total acidity of 0.64 per cent (calculated to H_2SO_4) containing sulphuric and acetic acids, a small amount of sulphurous acid and aromatic compounds of the type of pyrogallol. These liquors contain about 5½ per cent of reducible sugars calculated to dextrose. Polyphenols, tannin and furfurol are usually present in small amounts. These liquors are fermented and distilled in the usual manner, some care being required in the fermentation to have present a proper food for the yeast. The distilled alcohol obtained is potable, free from the odor and taste of wood, and from methyl alcohol and fusel oils, but contains traces of furfurol and aldehydes. One and one half tons of dry wood give about 6½ gallons of 94 per cent alcohol. From figures obtainable it appears that the efficiency of the process is from 75 to 80 per cent of the theoretical yield of alcohol.

The Dupont Powder Company is operating a plant at Georgetown, South Carolina, for the production of alcohol from waste woods. This plant is licensed under the Ewen and Tomlinson patents, and while no figures were obtainable, it is stated that experiments so far indicate the ultimate success of the process.

W. P. Cohoe is the inventor of a process for making fermentable glucose-like substances from cellulose and ligneous materials (U. S. Patents 985,725, 985,725, 1911). The conversion is done in two stages: first, steam is used producing acetic acid which is collected, and then steam and HCl vapors are introduced into the converter. The raw material used is generally sawdust.

The cost of production of alcohol by the sawdust process (Ruttan, *J. Soc. Chem. Ind.*, 1909, p. 1290) is said to be about equal to that of grain, although there is such an enormous difference between the cost of the raw materials. One company, however, claims to be able to manufacture alcohol by the sawdust process at a cost of 7 cents per gallon.

Without going into the details of the chemistry involved, it is striking that, although the patents claim conversion of cellulose into sugar, the so-called true fibrous cellulose, absorbent cotton, does not yield to this treatment. Also the material left after treatment contains cellulose which upon re-treatment yields but traces of fermentable sugar. Although authorities differ, it is claimed by some that the acid acts as a catalyzer hydrolyzing the lignone complex and a proportion of the "easily attacked cellulose." The oxycellulose and the "true cellulose" are said not to be seriously altered chemically.

It would seem that there is a possibility that a process might be evolved where the alcohol conversion of the wood pulp might be made first, and then the residue subsequently utilized for the production of paper pulp.

*Reproduced from the *Journal of Industrial and Engineering Chemistry.*

Langley's Book on Aviation*

A Classic in Practical Aerodynamics

With admirable dignity, completeness, and elegance, the Smithsonian Institution has finally published the first two of the three contemplated parts of the great memoir on mechanical flight, written by Dr. Langley and his assistant experimentalist, Mr. Charles M. Manly, and covering the long period of his work in aviation from its first inception in 1887 to its close in 1903.

The memoir as planned by the famous secretary of the Smithsonian Institution was prepared from the original carefully recorded accounts of the experiments described; for it was his custom, adopted generally by his associates, to preserve in suitable note books all ideas and designs, whether transitory or permanent, all suggestions, speculations, plans, inventions, computations, queries, so that in this manner he left amply recorded the current and intimate activities of his industrious, comprehensive, and fruitful life.

A felicitous outcome of the care with which these important experiments were recorded and finally published doubtless will be not only to confound and discredit Dr. Langley's detractors and relentless critics who, in high places and low places, passed such malign and imbecile judgment on the labors of an eminent man of science conducting, in a legitimate, methodical, and unobstructive manner, efficient and fruitful researches for the American Government, under the continued supervision and indorsement[1] of the War Department, but also to manifest to all fair-minded men the thoroughness, scope, and magnitude of his aeronautic labors, and to demonstrate that, after the prosecution of fundamental investigations in aerodynamics, he applied these to the design, the construction, and the successful launching of the first model dynamic aeroplane known in history to fly and balance itself in the air equipped with a practical motor, and followed this by the production of the first passenger aeroplane of adequate stability and power for prolonged flight.

Langley's entire work in aviation comprised three parts. These were, first, experiments in aerodynamics, to prove the physical possibility of artificial flight on a considerable scale, and to serve in aeronautical computations and design; secondly, experiments with models, to prove the mechanical possibility of building an engine-driven flying machine that could be actually launched and flown a long distance with good inherent equilibrium; thirdly, to develop for the United States War Department a passenger aeroplane adapted to practical use. To these occupations may be added his studies of the movements of the air and of the flight of birds, more particularly the soaring kind, with a view to explaining the phenomenon of passive flight in nature, and to satisfying himself of the feasibility of navigating a passenger soaring machine. These latter researches and speculations, however, do not form an integral part of the memoir, though the appendix contains an interesting study of the American buzzard and the "John Crow," but find their fullest public expression in his paper on "The Internal Work of the Wind," published in 1893.

Langley's measurements and researches in aerodynamics covered the entire period of his experiments, from 1887 to 1903. The earlier of these, devoted to the measurement of air resistance on plane surfaces, and the determinations of the thrust and power of air propellers, made on his large whirling table at Allegheny, Pa., were published in 1891. The succeeding experiments in aerodynamics, devoted mainly to curved surfaces and propellers, are still to be published, and will form an extension of the present memoir. From the data obtained in his earlier experiments, Langley concluded that "it was possible to construct machines which would give such a velocity to inclined surfaces that bodies indefinitely heavier than the air could be sustained upon it, and moved with great velocity."

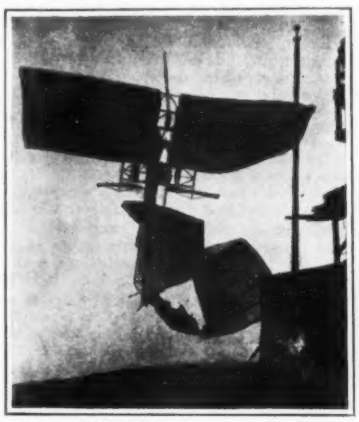


Photo. by Washington Star.

Attempted Launching of Full-sized Langley Aerodrome, December 8th, 1903. The Craft Was Injured in the Act of Launching.

Instantaneous Photograph of the Steam-driven Model in Its Successful Flight at Quantico on the Potomac River, May 6th, 1896.

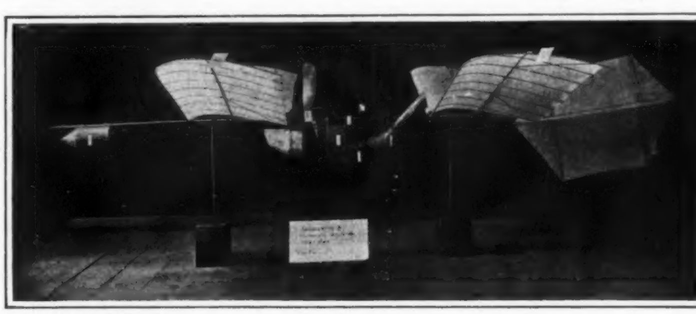


Photo. by Smithsonian Institution

Steam-driven Model. Langley's Aerodrome No. 6.

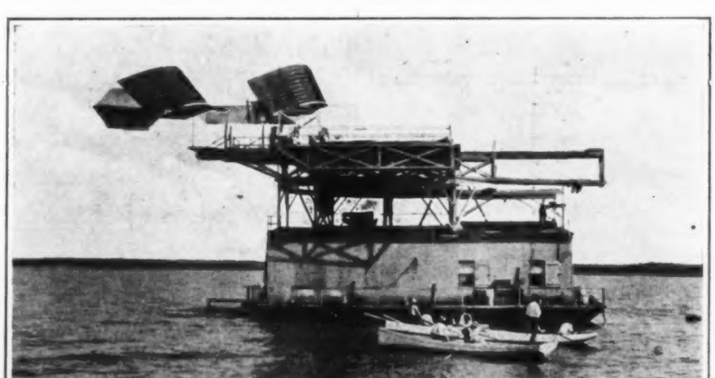


Photo. by Smithsonian Institution

Full-size Langley Aerodrome Ready for Launching October 7th, 1903, on the Potomac River, Near Widewater, Va.

Photo. by Smithsonian Institution

Rear View of the Full-sized Machine Before it was Launched on October 7th, 1903.

The second of Langley's labors, fairly current with the first and covering the nine-year period from 1887 to 1896, was the development of a model flying machine of considerable size and power, capable of long flights with good poise. Beginning with toy aeroplanes, driven by twisted rubber, he gradually improved his contrivances till he had produced a successful steam flying model. Very candidly he describes, in Part I of his most interesting memoir, this long series of experiments, with the attendant failures, and recounts how he learned for himself many important principles and facts in aviation which every well-read student of aeronautics had by heart. "The experiments with rubber-driven models," he informs us, "commenced in April, 1887, at the Allegheny Observatory, were continued at intervals (partly there, but chiefly in Washington) for three or four years, during which time between thirty and forty independent models were constructed, which were so greatly altered in the course of experiment that more nearly one hundred models were in reality tried. The result of all this extended labor was wholly inconclusive; but as subsequent trials of other motors (such as compressed air, carbonic acid gas, electric batteries, and the like) proved futile, and (before the steam engine) only the rubber gave results, however unsatisfactory, in actual flight, from which anything could be learned, I shall give some brief account of these experiments, which preceded and proved the necessity of using the steam engine, or other like energetic motor, even in experimental models."

Following the experiments with small rubber-driven models, Dr. Langley developed his famous steam model, then his still more important gasoline model, both of which flew successfully and are now to be seen in the American Museum.

The steam model, launched in May, 1896, is a tandem monoplane with twin screws amidships. It measures about 16 feet in entire length, 13 feet across, and weighs with motor and propellers 30 pounds, the boiler weighting 5 pounds, the engine 26 ounces, and developing between 1 and 1.5 horse-power. When launched from a catapult on top of a house boat in the Potomac River the little "aerodrome" flew in stable poise for rather more than half a mile, and landed gently on the surface of the river. Its flight could easily have been prolonged by a larger supply of fuel, but this was purposely limited in order to prevent the machine from flying too far, and possibly being lost in the woods bordering the river. This was Langley's first experimental demonstration of the practicability of mechanical flight.

Dr. Langley now thought his work in aviation finished, but in 1898 he received from the United States War Department $50,000 to develop a passenger machine for military purposes. He then engaged Mr. Manly, just graduated from Cornell University, to act as chief engineer in this new and arduous enterprise. After five years of careful scientific experimentation a gasoline-driven aeroplane having the general aerodynamic features of the steam model was finally perfected, and seemed well qualified to carry a passenger on a long cruise. A quarter-scale model of the passenger machine was constructed also, to be tested first, to obviate the risk of wrecking the large machine, due to inadequate experience in adjustment and launching.

This gasoline model was rather larger than the steam model, and radically superior to it in propulsive power. It spread 66 square feet of surface, weighed 58 pounds, and developed 2.5 to 3 horse-power. It was flown privately many times both with single-surface wings and with superposed surfaces, and on August 8th, 1903, made a beautiful flight in public, manifest-

* Langley Memoir on Mechanical Flight. Parts I and II. Langley's Experiments With Models and Passenger Aeroplane. Part I by S. P. Langley; Part II by C. M. Manly. Washington: The Smithsonian Institution, 1911. 4to.; 320 pp.; diagrams and half tones.

[1] The War Department made no allotment to continue Langley's experiments, fearing the displeasure of Congress, owing to adverse newspaper criticism.

ing good automatic control. It was capable of a continuous voyage of many miles, but, owing to lack of time for the tests, its powers were never fully revealed.

Langley's gasoline model of 1903 was the most advanced achievement in the history of aviation up to that date, and represented not only the mechanical possibility of flight, but also the first substantial accomplishment thereof, and the first public exhibition of a system of flight capable of practical use. It was indeed the first approximate solution of the real problem of the ages in aviation—the development of a suitable motor. For the invention of an adequate motor always had been, and still is, by far the greatest difficulty in the art of flying; one may say the only really formidable difficulty. Every tyro should be able to provide for inherent stability in an aeroplane, should be able to contrive automatic stabilizing mechanisms, should be able to hit upon the three-rudder system of control, which was proposed or patented by so many men before the year 1900. But who, before Dr. Langley, made a suitable gasoline motor and drove an aeroplane with it? Who at the present day of much flying and munificent stimulus can give the world a better motor than the gasoline engine, that super-refined and delicate heart of the aeroplane which no pilot can fully trust, and on whose pulsation his life may depend? The addition of wheels and skids to an aeroplane, and the various improved controlling mechanisms, are obvious improvements compared with the fundamental task, never yet fully accomplished, of providing adequate and reliable power.

Langley's large aeroplane, which was the culminating achievement of his long years of research and experimentation, was the first flying machine of adequate stability and power to carry a passenger in prolonged flight. This may be affirmed, first, from its specifications, which competent aeronautical engineers can easily appreciate; secondly, from the performances of the quarter-scale model, which proved its navigating qualities in many successful flights; thirdly from the fact that Blériot several times practically operated an aeroplane which was substantially a duplicate of Langley's.

The large "aerodrome," like its smaller prototype, was a tandem monoplane driven by twin screws amidships. It weighed 830 pounds, including the pilot; spread 1,040 square feet of wing surface; measured 48 feet from tip to tip of its wings, and 52 feet fore and aft; soared at 33 feet a second and at a 10-degree angle of incidence. It was driven by a gasoline engine of 52.4 horse-power, weighing with all accessories 200 pounds, and could carry fuel enough for a continuous flight of many hours. It possessed sufficient automatic stability for successful flight in ordinary weather. Furthermore, the pilot could control its poise and direction by means of a horizontal and a vertical rudder, and by shifting his weight laterally or longitudinally in the small boat fixed amidships, which he should occupy during flight. In truth, the machine was as well equipped for automatic stability and manual control as some of the prominent prize-winning fliers at the first international meet, held at Rheims six years later, notably the "Antoinette" and "Voisin" aeroplanes.

An unfortunate accident in the launching of this elaborately perfected flying machine, an accident which nowadays would be regarded as a trivial incident to be expected in the early trials of a craft so complex and original, deprived Dr. Langley and his associates of the gratification and credit of effectively inaugurating the era of practical aviation, and entailed on his crowning achievement unmerited obloquy and misjudgment which only time can efface. But with all the facts fully set forth, competent engineers can estimate the true worth of those arduous experiments, and deliberate history may redress the mischief of a misguided or malevolent press. In this estimate it is to be remembered that those final tests were but demonstrative and transitional; for after proving the power, endurance, and stability of his machine, Langley meant to adapt it to practical use by the addition of further devices for launching, landing, and effective manual control in the air. It is to be remembered also that Langley, like his distinguished colleague, Mr. Octave Chanute, by his position and attainments, enhanced the general regard for the pursuit of aviation, stimulated capable votaries in either hemisphere to make important researches, and aided them by correspondence or substantial grants; for he was governed by a lofty and true scientific spirit that withheld no facts, from mercenary motives, discouraged no rival, and aspired to no commercial monopoly in the art he was developing.

In felicitating the Smithsonian Institution on the first installment of this splendid memoir, it is a pleasure to animadvert to the devoted labor of Mr. Charles M. Manly. He was the responsible engineer in charge of Langley's aeroplane work from 1898 to the close of the experiments in December, 1903; he was the confidential secretary and adviser to his chief in that whole enterprise. When in 1900 Langley stood baffled before the greatest obstacle in aviation, unable to find any manufacturer in America or Europe who could furnish an adequate motor, Manly came to his rescue with the design which he eventually embodied in what may be called the first engine suitable for human flight on a practical scale. Finally, when the aeroplane was ready, it was Manly who bore the long weeks of trial in the malarial region of Widewater, harassed by accidents and foul weather, and it was he who twice rode the ponderous "aerodrome," shot forth in mid-air from the top of the house boat, at the imminent risk of his life. It is interesting to note at the close of the memoir on which he spent so much valuable time that he is now preparing to resume work on the large aeroplane at the earliest opportunity, and that the machine will be used in practically the form it had at the previous trials, except for a slight change to permit launching it over ground rather than over water. It is to be hoped that this final test will amply vindicate his and Dr. Langley's judgment that the machine is correct, both in principle and construction, and therefore merits recognition as the first passenger flying machine capable of a prolonged voyage in the air.

NEW BOOKS, ETC.

WOOD PULP AND ITS USES. By C. F. Cross, E. J. Bevan, and R. W. Sindall. With Illustrations. New York: D. Van Nostrand Company, 1911. Small 8vo.; 270 pp. Price, $2.

Here we have an excellent popular book on the applications of wood pulp, and the possibilities and limitations of an industry of which the average man knows only too little. The book systematically begins with the growing tree and the structural elements of wood. Then comes a discussion of cellulose as a chemical individual and typical colloid, the lignone complex, ligno-cellulose, and the researches of W. J. Russel are next explained. Most important is the chapter on wood pulps in relation to sources of supply. That question the economist or the financier approaches from a point of view that is not that of the chemist. The problem is, What is the rate of consumption and what are the sources of supply? The authors have nailed down many sensational tales about the number of trees daily sacrificed to produce a single edition of a newspaper with large circulation, and they have shown that the world's demand in 1907-1908 amounted to 4,628,000 air-dry tons, divided very nearly equally between mechanical pulp and chemical pulp. But while millions of cords of wood were turned into pulp, the quantity is not likely to grow less with time. Indeed, Canadian pulp proprietors assert that they can run a mill, producing 6,000 tons of pulp annually, on a grant of 25,000 acres with a forty years' rotation. Hence, the prospect of permanent investments looks brighter. Interesting too is the chapter on the utilization of wood waste, in which is pointed out the many applications of wood pulp.

THE SHIPPING WORLD YEAR BOOK. A Desk Manual in Trade, Commerce, and Navigation. Edited by Evan Rowland Jones, 1912. London: The Shipping World Offices. 12mo.; 1,800 pp.; with new map of the world.

This British annual comes to us in the same familiar form. The usual accurate information regarding ships and shipping, customs, tariffs and ports is dispensed. Outside of the port directory of the world and the revised tariffs of all nations, the new features for 1912 include tables of freeboard, life-saving regulations, a digest of the Merchant Shipping Acts of Great Britain from 1894 to 1911, a list of Post Office radio-telegraphic stations in the British Isles, abstract of the Suez canal regulations with list of principal shipowners and their tonnage that pay dues, British mail payments and subsidies to the Cunard and Royal Mail Steam Packet Companies, the reduced cable rates, useful addresses, foreign trade statistics for 1911, details of the world's shipping output for the same year, and a list of the fastest merchant ships now in existence. The large folding map of the world is again a valuable accessory of the work.

DIE BEARBEITUNG DES GLASES AUF DEM BLASETISCHE. Ein Handbuch fuer Studierende, welche sich mit wissenschaftlichen Versuchen beschaeftigen. Von D. Jakonow und W. Lermantoff, Laboranten der Kaiserlichen Universitat St. Petersburg. Berlin: Verlag von R. Friedlander & Sohn, 1911. 196 pp, 34 illustrations.

It is rarely indeed that a workman sits down and writes a book for the purpose of training others in his own calling. He is usually unable to write. For that reason, most so-called handbooks for the education of those who wish to take up certain trades, are written by men who are more familiar with the use of the pen than with the chisel or mallet. No matter how conscientious the efforts of such a literary man with a smattering of a trade may be, he is not likely to elucidate those points which are of most importance in the training of the novice. These faults can hardly be leveled at the work which lies before us. The late Mr. Djakanow, as his collaborator, Mr. Lermantoof, informs us, was an academically educated man and also an experienced and skillful glass blower. Despite Djakanow's unquestioned competency and that of Mr. Lermantoof himself, it was deemed advisable to submit this book to Messrs. Franz and Oscar Mueller, who are regarded as the two most skillful glass blowers in St. Petersburg. Mr. O. Mueller repeated many of the experiments described in this book, and has checked up the accuracy of the descriptions.

Beginning with a description of the physical process of glass formation and the forces which play a part in that process (surface tension, hydrostatic pressure of air, gravity) and with a discussion of the necessity of knowing the art of the glass blower for experimental purposes, the authors pass to a description of the instruments used, the material employed by the glass blower, the various manipulations required for the formation of different objects in glass, the construction of entire pieces of apparatus, and the finishing and calibration of thermometers.

THE PROBLEMS OF PHILOSOPHY. By Bertrand Russell, M.A., F.R.S. New York: Henry Holt & Co. 16mo.; 255 pp. Price, 50 cents net; by mail, 56 cents.

This is really a primer of philosophy—an excellent little study preparatory to entering upon a more extended course of reading. It states in common language our knowledge and our limitations in regard to the phenomena of life; the source of our concepts and the means we have of assuring ourselves of their truth or falsity; the arguments as to the existence and nature of matter; the wrangle between the empiricists and the rationalists. It explains what is termed *a prior* knowledge, and leads up to a discussion of the world of universals and of intuitive knowledge. Incidentally, the system of the leading philosophers and schools are dissected and summarized. There are places where the phraseology becomes somewhat involved and bewildering, but this is a drawback well-nigh inseparable from so difficult a subject. Altogether the author's success is remarkable, and his lack of bias most commendable.

ARCHITECTURE. An Introduction to the History and Theory of the Art of Building. By W. R. Lethaby. New York: Henry Holt & Co., 1912. 16mo.; 256 pp.; illustrated. Price, 50 cents net; by mail, 56 cents.

Whether one wishes to get the best out of life at home, or to reach an appreciative understanding of the monuments of mankind in older civilizations, some general knowledge of architecture is necessary. The little work in hand starts with what we know of the origins of architecture, and brings us down through Egyptian practice and Greek and Roman art to the more modern developments. The paper used and the small size of the page lend themselves but poorly to illustration. Aside from this the material is well arranged, pleasing, and informing. The book is from the "Home University Library" of popularly-written educational works.

FARM IMPLEMENT NEWS BUYER'S GUIDE. Vol. XXII. Chicago: Farm Implement News Company, 1912. 8vo.; 496 pp.

This is a classified directory of manufacturers of farm and garden implements, wagons, carriages, automobiles, cream separators, gasoline engines, wind mills, pumps, wire fencing and other lines of interest to agriculturists. Farm implements and accessories are first alphabetically listed; then vehicles; while, where the trade name of articles appear, a key-number makes easy reference to the manufacturer. These manufacturers make up the body of the directory, which thus gives access to much information of importance to the users of farm implements and equipments.

CEILINGS AND THEIR DECORATION. Art and Archæology. By Guy Cadogan Rothery. New York: Frederick A. Stokes Company. 8vo.; 281 pp.; illustrated. Price, $1.50.

The volume is one of a series on the architectural embellishments of a home—the inglenook, the staircase, the porch, and the windows—and is planned in the conviction that a proper respect for antiquity assists in applying art to modern requirements. Out of a study of the ceilings of the ancients, the Byzantine and the Mauresque, mosaics, Gothic and Renaissance ceilings, timber, carved wood and plaster work, the writer seeks to develop good taste, rejecting such old practice as conflicts with our best modern concepts and retaining whatever seems to the inspired mind and the trained judgment good and delightful. The illustrations show some fine examples of old ceilings, and in his paper on "Present Day Practice" the writer has sketched the various constructions of plaster, of metal, of ferro-concrete, and of exposed joists and boards. Advantages and disadvantages are duly weighed, and artistic values carefully computed and compared. A chaptêr on "Lighting" fittingly concludes what is on the whole a most helpful discussion.

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